



U.S. Army Corps of Engineers  
Water Resources Support Center  
Institute for Water Resources

AD-A281 082



# ***Infrastructure in the 21st Century Economy: A Review of the Issues and Outline of a Study of the Impacts of Federal Infrastructure Investments***

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**Federal Infrastructure Strategy Program**



## Federal Infrastructure Strategy Reports

This is the fourth in a series of interim reports prepared to support the Federal Infrastructure Strategy Initiative, a 3-year program to explore the development of an integrated multi-agency Federal infrastructure strategy.

The Federal Infrastructure Strategy Initiative is a dynamic program involving many Government departments and agencies. The series of reports which chronicle the strategy's development reflect the desire to publish interim documentation as results become available. These documents will be used to facilitate the dialogue within the Federal and non-Federal infrastructure communities as policy deliberations continue.

The program will culminate with a final report to be published at the end of 1993. The interim documentation contained herein is not intended to foreclose or preclude the program's final conclusions and recommendations. Within this context, comments are welcome on any of these reports.

This report documents the results of an in-depth study and workshop which developed methods which could be applied to overcome barriers to innovation and the use of innovative technology within the nation's public works infrastructure.

The first three reports published as part of the Federal Infrastructure Strategy Program were:

The Federal Infrastructure Strategy Program: Framing the Dialogue - Strategies, Issues and Opportunities (IWR Report 93-FIS-1)

Challenges and Opportunities for Innovation in the Public Works Infrastructure, Volumes I and II, (IWR Reports 93-FIS-2 and 93-FIS-3); and

The next report planned for publication as part of the program is:

Federal Public Works Infrastructure R&D: A New Perspective (IWR Report 93-FIS-5).

For further information on the Federal Infrastructure Strategy Program, please contact Robert A. Pietrowsky, Program Manager at :

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The Federal Infrastructure Strategy team includes Cameron E. Gordon, Economics Studies Manager and James F. Thompson, Jr., Engineering Studies Manager. The program is overseen by Dr. Eugene Z. Stakhiv, Chief of the Policy and Special Studies Division, and Kyle Schilling, Director of the Institute.

Reports may be ordered by writing (above address) or calling Arlene Nurthen, IWR Publications, at 703/355-3042.



REPLY TO  
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June 24, 1994



CEWRC-IWR

MEMORANDUM FOR COMMANDER, Defense Technical Information Center,  
Cameron Station, Alexandria, VA 22314

SUBJECT: Transmittal of IWR Report 93-FIS-4

1. Reference AR 70-31.
2. Two copies of IWR Report 93-FIS-4, "Infrastructure in the 21st Century Economy: A Review of the Issues and Outline of a Study of the Impacts of Federal Infrastructure Investments", has hereby been submitted
3. Initial distribution of this report has been made to appropriate Corps of Engineers agencies. It is recommended that copies of this report be forwarded to the National Technical Information Center.
4. Request for the DTIC Form 50 (Incl 2) be completed and returned to WRSC-IWR.

FOR THE DIRECTOR:

Kyle E. Schilling  
Director

Enclosure



**The Federal Infrastructure  
Strategy Program**

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**INFRASTRUCTURE IN THE 21ST CENTURY ECONOMY:  
A REVIEW OF THE ISSUES AND OUTLINE OF  
STUDY OF THE IMPACTS OF FEDERAL  
INFRASTRUCTURE INVESTMENTS**

by

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JULY 1993

IWR REPORT 93-FIS-4

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## Infrastructure in the 21st Century Economy

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### ACKNOWLEDGEMENTS

This study is a cross-cutting effort which examines infrastructure programs within the Corps of Engineers, and in other Federal agencies, and whose development has been aided by and continues to be participated in by representatives from many Federal and non-Federal organizations. As such, there are many people to acknowledge who provided contributions of time and insight which led to the development of this effort, reviewed the many draft scopes of work which preceded this effort, reviewed this report itself and who are continuing to participate in the ongoing work. A list of these participants can be found in Appendix B. Without their past and continued efforts, this study would not have come to pass in the form it did.

The study has been coordinated, and this report was principally authored by Mr. Cameron Gordon (Economics Study Manager). Mr. Robert Pietrowsky (Federal Infrastructure Strategy Program Manager) and Dr. Eugene Stakhiv (Chief of the Policy and Special Studies Division of the Institute for Water Resources), have overseen the effort and provided much counsel and guidance on the overall direction of the work. Dr. Robert Stearns (Deputy Assistant Secretary of the Army for Project Management [Civil Works]) chaired the first two workshops and Mr. Kyle Schilling, Director of the Institute for Water Resources, chaired the final meeting; both provided much useful additional guidance.

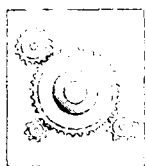
As usual, many others provided invaluable comments and review. Once again, readers are referred to Appendix B for a full list of the people who were sent review copies of this report. Special mention must be made of Mr. Dennis Robinson and Dr. L. George Antle, Senior Economist and Chief respectively, with the Navigation Division of the Institute for Water Resources, and Mr. Michael Krouse and Dr. David Moser, Senior Economist and Chief respectively, with the Research Division of the Institute for Water Resources. Ms. Jan Peterson spent many hours editing and formatting the various drafts to make them polished enough for the final version.

Finally, this report does not reflect the official views or policies of the Department of the Army or the Corps of Engineers.



ACKNOWLEDGEMENTS iii

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## Infrastructure in the 21st Century Economy

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## **EXECUTIVE SUMMARY**

The U.S. Army Corps of Engineers, through its Institute for Water Resources, has commenced an ongoing interagency study to assess the relationship of Federal infrastructure - specifically investments in water, waste management, and transportation - to the Nation's productivity, economic health, and quality of life.

This report describes this effort and the process by which the study's workplan was derived. This report covers three main topics:

1. **A discussion of what previous research does, and does not, tell Federal policymakers about the economic impacts of infrastructure investments;**
2. **A description of the findings of a series of interagency workshops with invited academic experts regarding the objectives of and methodological approaches for the current foundation of an economic policy study of infrastructure investments; and**
3. **An outline of the goals and activities associated with this study.**

### **The Current State of Research**

There is currently much debate over the cause and effect relationships between infrastructure and the economy. The services which infrastructure provide, such as the improvement in mobility provided by a new bridge, can change economic output either by affecting suppliers of goods and services or by affecting total demand for those goods and services (infrastructure demand being one component of that overall demand). Four main channels of causation have been identified:

**Causal Effect #1: The services provided by public capital can be a direct input into private production.**

**Causal Effect #2: The services provided by public capital can affect private output by increasing the productivity of other privately provided inputs.**





**Causal Effect #3: The services and amenities provided by infrastructure can create an environment which draws inputs from other areas.**

**Causal Effect #4: The building and maintenance of facilities can create temporary new demands for goods and services and thus raise the level of economic activity.**

In general, there is agreement that the services provided by infrastructure, broadly defined to include all types of public works, have a positive effect on measured output. Empirical results generally show that infrastructure's positive impact on production is greatest at the national level. As the level of analysis gets more specific (e.g. from nation to region to state to city), the positive effects of infrastructure on output appear to become smaller, perhaps because the impacts become increasingly difficult to detect.

While research thus far generally confirms that infrastructure has a positive effect on economic output, it may not always have a positive effect. The following points should be kept in mind when examining the economic impacts of public works:

- 1. While most estimates confirm infrastructure's positive effect on economic activity, a few estimates do not.**
- 2. There is no consensus on the extent to which infrastructure is a cause or an effect of economic growth, since statistical analysis often cannot identify the direction of the cause-effect relationship.**
- 3. Infrastructure affects quality of life as well as the economy, but these effects are difficult to quantify.**
- 4. Services provided by facilities, rather than the facilities themselves, are most important to long-run economic growth.**
- 5. Users of infrastructure should be commensurately charged for the services they receive.**
- 6. It is possible to invest too much, as well as too little, in infrastructure.**
- 7. It is cost-effective to properly maintain infrastructure.**
- 8. A positive impact of an infrastructure investment in gross terms can become neutral or negative after the costs of the investment are subtracted out.**

All of the statements above apply "on average" - that is to say, while the sum of all public works investments has a positive national impact, particular public works projects are

inherently local and their effects are closely tied to the local circumstances in which they operate.

General statements about infrastructure's relationship to the economy are difficult to make in part because of the limitations which have faced researchers in this field. The policy implications which can be drawn from the existing literature, particularly for the Federal government, are also often limited. Some of the reasons for the tentative or broad nature of many of the present conclusions about infrastructure's relationship to economic growth and appropriate policies to undertake, include the following:

- 1. The complexity of the problem.**
- 2. The fact that different researchers have used different models, sometimes asked different questions, and used different data.**
- 3. Incomplete and limited data.**
- 4. Problems with model estimation and econometric analysis .**
- 5. Focus on separate public works categories rather than infrastructure as a system.**
- 6. A lack of policy focus in most studies.**

### **The Findings of the Three Interagency Workshops**

To examine the infrastructure debate more fully, three one-day workshops were held on July 16, September 17, and November 6, 1992 and were attended by staff from the following Federal agencies:

U.S. Department of the Army, including the Corps of Engineers  
U.S. Department of Agriculture  
U.S. Department of Commerce: Bureau of Economic Analysis  
U.S. Department of Energy  
U.S. Environmental Protection Agency  
U.S. Department of the Interior: Bureau of Reclamation  
U.S. Department of Transportation:  
    Federal Aviation Administration,  
    Federal Highway Administration,  
    Federal Railroad Administration, and  
    Federal Transit Administration  
U.S. Office of Management and Budget



Representatives from the Congressional Budget Office, Congressional Research Service, Federal Reserve Banks of Boston and Cleveland and various academic institutions also attended. A list of the attendees who were not from the Corps of Engineers is included in Table ES-1 at the end of this executive summary.

Participants generally agreed that publication of further literature surveys was not needed and that economic theory alone had been pushed as far as it would go. What was needed was more original, comprehensive, and policy-relevant empirical work and analysis.

Questions of spillover, external economies, and network effects of public capital, the effect of infrastructure on economic structure and guidelines for allocating Federal resources across investments were seen as key questions for study. While short-term economic impacts are clearly important, participants opted for focusing on the medium and long-run impacts of Federal investments planned for the next five years.

Most thought that the scope of Federally provided and leveraged infrastructure could include a variety of investments but that for the sake of manageability, the Fragile Foundations categories of water resources, (such as flood control, ports, and inland waterways) water supply and wastewater treatment, transportation (mass, air and highways), and waste management (solid and hazardous) would be acceptable. Participants also felt, however, that these categories should be examined in alternative ways, such as splitting the traditional modes of transportation categories into outputs such as intercity passenger transportation and intercity freight, to name one example.

It was also recognized that non-economic impacts of public works were very important and should be described and quantified where possible even if non-systematically. Participants agreed that there was a need for more original and better data and that while one needs to understand the past to understand the future, the study should systematically attempt to make some predictions about future impacts. Finally, a controlled comparison, run on comparable data, of the production function and a generalized cost-benefit analysis at the program level was seen as a useful way of discerning the effects of methodologies on inferences.

## **The Current Effort**

Conceptually, the work consists of four broad tasks, each of which is designed to deal with some of the challenges faced in prior research which has kept guidance to Federal policymakers fairly limited. These tasks, which will be fleshed out and expanded later with case studies and other analytic techniques, are:

**1. Organization of an Analytic Framework:** To meet the challenge of conducting a comprehensive analysis of the economic and non-economic impacts of the Federal infrastructure

system, the study is developing an overall framework to account for all costs and benefits, broadly defined, of Federal infrastructure investment.

**2. Data Collection:** One must have high quality data regarding appropriate and relevant phenomena. Given the interagency nature of this effort, it is hoped that a fully catalogued list of Federal data will identify consistencies and inconsistencies and data gaps that, if closed, might shed light on the nature, quality and quantity of services offered by the existing Federal capital stock.

**3. Comparison:** Much of the uncertainty surrounding the size of the economic impact of public works expenditures may be due to differences in methodologies. To untangle some of these issues, the core of the effort is a controlled comparison, on comparable data, between broad benefit-cost analyses of investments in infrastructure modes and production or cost function analyses of the same investments. (Benefit-cost analysis is here defined as the quantification and classification of some investment impacts as costs to society and others as benefits, using specified criteria such as willingness-to-pay, and then netting out the difference between the two to determine whether the investment impacts represent a net gain or loss to society). Analysis of economic impacts will start at the national level; additional analysis at the regional, state, and local levels, and by more detailed expenditure category, is desired, but may not be accomplished depending on limitations of time, resources and data.

**4. Simulations:** This study aims to be relevant to policymakers, particularly those at the Federal level. One way of ensuring this relevance is to focus on Federal programs. Another way is to simulate the economic impacts of planned Federal infrastructure investments in the future, and comparing this simulation with an explicit and predefined baseline. Future projects will be evaluated using prospective simulations of both benefit-cost and production function analysis.

Of course, to understand the future, one must understand the past. Retrospective analysis is a key part of the study, and the impacts of past investments on past economic performance will be assessed to better understand economic dynamics, potential causal relationships, and the workings of different analytic models. However, the main output of this study will be a simulation of future economic impacts of current and future Federal infrastructure investments.

### **Next Steps**

The study will continue to be guided by interagency management and review committees and non-Federal experts will be called in to lead the broad conceptualization of the cost-benefit and production function analyses.



Interim products will include:

**A report describing current and planned Federal infrastructure programs**, which will take the data collected from Federal agencies, and describe and quantify current Federal public works investment plans.

**A report describing work in progress** serving as a status report on the effort, revealing what has been uncovered, what remains to be examined, and how.

**A report on the simulation of economic effects of Federal infrastructure**, which will describe the way in which simulations have been undertaken and preliminary results of these simulations.

**Reports on various extensions of the analysis**, case studies and a synthesis report.

**Table ES-1: Non-Corps of Engineers Workshop Participants**

David Aschauer	-	BATES COLLEGE
Michael Bell	-	JOHNS HOPKINS UNIVERSITY
Carolyn Cannon	-	U.S. DEPARTMENT OF ENERGY
Michael Dean	-	U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA): OFFICE WATER
Michael Deich	-	U.S. CONGRESSIONAL BUDGET OFFICE (currently with the NATIONAL ECONOMIC COUNCIL)
Alan Dickerson	-	U.S. DEPARTMENT OF THE INTERIOR: BUREAU OF RECLAMATION
Randall Eberts	-	FEDERAL RESERVE BANK OF CLEVELAND
Frank Emerson	-	U.S. DEPARTMENT OF TRANSPORTATION: FEDERAL AVIATION AUTHORITY
William Gelston	-	U.S. DEPARTMENT OF TRANSPORTATION: FEDERAL RAILROAD ADMINISTRATION
Ann Grambsch	-	EPA: OFFICE OF POLICY, PLANNING, AND EVALUATION
Thomas Hady	-	U.S. DEPARTMENT OF AGRICULTURE: ECONOMIC RESEARCH SERVICE
Arthur Jacoby	-	U.S. DEPARTMENT OF TRANSPORTATION: FEDERAL HIGHWAY ADMINISTRATION
Kurt Karl	-	WEFA GROUP, INC.
John Kort	-	U.S. DEPARTMENT OF COMMERCE: BUREAU OF ECONOMIC ANALYSIS
John Love	-	APOGEE RESEARCH, INC.
Randolph Lyon	-	U.S. OFFICE OF MANAGEMENT AND BUDGET
Al McGartland	-	EPA: OFFICE OF POLICY, PLANNING AND EVALUATION
Ronald Moomaw	-	UNIVERSITY OF OKLAHOMA
Alicia Munnell	-	FEDERAL RESERVE BANK OF BOSTON (currently Deputy Assistant Secretary of the Treasury for Economic Policy)
Ishaq Nadiri	-	NEW YORK UNIVERSITY
Gene Pontillo	-	EPA: OFFICE OF THE COMPTROLLER
Adam Rose	-	PENNSYLVANIA STATE UNIVERSITY
Kenneth Rubin	-	APOGEE RESEARCH, INC.
Norman Starler	-	U.S. OFFICE OF MANAGEMENT AND BUDGET
Robert Stearns	-	U.S. DEPARTMENT OF THE ARMY, Office of Assistant Secretary of the Army (Civil Works)
Robert Wescott	-	WEFA GROUP, INC.
Fred Williams	-	U.S. DEPARTMENT OF TRANSPORTATION: FEDERAL TRANSIT ADMINISTRATION





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### INTRODUCTION

In the late 1970's and early 1980's, when state and local infrastructure budgets were stretched thin and some major cities were in, or in danger of, default, aging infrastructure and the lack of resources to refurbish that infrastructure entered into the national policy debate. A 1984 report by Pat Choate and Susan Walters entitled America in Ruins: The Decaying Infrastructure, argued that "America's public facilities are wearing out faster than they are being replaced" and that the resultant bottlenecks and deteriorated services from this public disinvestment would hinder the functioning of the American economy.

Another report on the same topic was issued around the same time by the Congressional Budget Office (CBO) and was titled Public Works Infrastructure: Policy Considerations for the 1980's. CBO analyzed specific investment needs in highways, public transit, wastewater treatment, water resources, air traffic control, airports, and municipal water supply. While the study authors found some unmet needs, they also claimed that many modes were functioning adequately at present funding levels, that traditional needs studies often overstated requirements for new resources, that some current spending priorities should be reordered rather than increased, and that certain problems with deteriorating services were, in fact, due to overuse caused by inadequate pricing.

Much has been written on the topic of infrastructure since then, but in many ways the debate continues along the same lines as suggested by the juxtaposition of the CBO and America in Ruins reports. Congress established the National Council on Public Works Improvement (NCPWI) to study the infrastructure issue from a national perspective. CBO conducted its own set of analyses. The result of these activities were the NCPWI report Fragile Foundations, issued in 1988, and the CBO report How Federal Spending for Infrastructure and Other Public Investments Affects the Economy, issued in 1991.

A comparison of these two reports reveals that many of the fundamental issues surrounding Federal infrastructure investment are still open. Fragile Foundations concluded that the Nation's infrastructure was "barely adequate to fulfill current requirements and insufficient to meet the demands of future economic growth and development." While maintaining that better management, accounting, financing, and technology practices were called for, the study nonetheless called for a doubling of infrastructure investment by all levels of government by the year 2000.



The CBO study was far more reserved in its statements regarding Federal infrastructure investments. The report stated that:

*carefully chosen Federal investments in physical infrastructure such as highway and aviation projects would yield economic rates of return higher than the average rate of return on private capital. As a rule, the highest economic benefits would result from maintaining existing infrastructure assets and from expanding capacity in highly congested facilities. Substantial economic benefits also can be achieved by using existing assets more efficiently. In many cases, price mechanisms can significantly increase the efficiency with which infrastructure is used ... Although further, carefully selected investments in public infrastructure may well be productive, there is little evidence that substantial, across-the-board increases in current programs would be more productive on average than private investment.<sup>1</sup>*

Academic research into the topic has not been much more conclusive and the fault lines in that debate have been similar. David Aschauer's work has noted the decline in public investment, measured as a percentage of gross national product over the last two decades, and has identified that decline as an important source of the concomitant fall in American productivity over the same period.<sup>2</sup> Other economists have challenged these results as empirically unsound and have argued that the existing stock of public capital is more or less adequate, although in need of better pricing and maintenance.<sup>3</sup>

Meanwhile, the Federal government invests over \$50 billion annually in non-military capital in the form of grants or direct expenditures.<sup>4</sup> At present, however, there is little consensus on whether that amount of investment is too much, too little, or just about right; how those investments affect or are affected by economic growth, development, and structure; or what the rates of return are to different broad categories of investment. Without some reliable and generally accepted answers to these questions, it is difficult to develop a long-range, coherent Federal infrastructure investment strategy. A study designed to arrive at some of these answers and to mitigate or avoid some of the pitfalls into which prior work has fallen is in order.

## **Purpose and Scope of This Report**

The purpose of this report is to describe an ongoing interagency study, commenced by the U.S. Army Corps of Engineers, through the Institute for Water Resources, to assess the relationship of Federal infrastructure - specifically investments in waste management, water, and transportation - to the Nation's productivity, economic health, and quality of life.

After briefly noting the history of the Corps' involvement in infrastructure studies generally, this report will describe the current state of knowledge about infrastructure's role in economic growth and development. It will be argued that, beyond broad principles, not much firm policy guidance is forthcoming from existing knowledge, and that some of these





uncertainties arise from limitations in the data, methodology, and research focus of the work done to date.

A description of the findings of a series of workshops follows, held by the Corps, in which individuals from Federal agencies, Congressional organizations and academic institutions were invited to examine issues surrounding formulation of a scope of work to address Federal policy needs and mitigate some of the problems encountered in previous research.

Having discussed the limitations of current knowledge and having described the proceedings of workshop sessions devoted to fleshing out strategies for overcoming those limitations, this report will conclude by describing the objectives of this effort, the means settled upon to achieve those goals, and the plan of work.

As part of this discussion, a number of appendices are included as background. These appendices include:

**Appendix A:** Scope of work for this study of infrastructure's economic impacts

**Appendix B:** Selected paraphrase proceedings of workshops and list of workshop attendees

**Appendix C:** Infrastructure bibliography arranged alphabetically by topic

**Appendix D:** Infrastructure bibliography arranged alphabetically by author





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### CONTEXT

#### Authority and Scope of the Federal Infrastructure Strategy Program

The effort to examine the economic impacts of Federal infrastructure investments is part of a larger Federal Infrastructure Strategy (FIS) program of studies and research developed by the Corps in accordance with an Administration budget initiative. House Report 101-536, accompanying the Energy and Water Development Appropriations Act of 1991, gave the U.S. Army Corps of Engineers responsibility for coordinating this initiative and emphasized that the effort pursue "opportunities for providing local infrastructure facilities" through a partnership between Federal agencies, state and local governments, and the private sector. Consideration was to be given to planning, designing, financing, constructing, operating, and maintaining the Nation's infrastructure with special mention made of identifying public/private financing opportunities.

From this charge, the Army Corps of Engineers, through the Institute for Water Resources (Policy and Special Studies Division) has developed a wide-ranging program to examine the Federal role in infrastructure provision. One of these efforts, the subject of this report, is a study to better understand the ways in which Federally provided and leveraged infrastructure investment affect the economy and society at large. The FIS program, and this study, generally focus on infrastructure spending in transportation, in this case consisting of mass transit, aviation and highways; waste management, consisting of hazardous and solid waste disposal; and water, consisting of wastewater treatment, water resources, and water supply.

The aggregate Fragile Foundations categories include analysis of a multiplicity of investments. For example, among the investments analyzed under the rubric of the broader classifications are:

**WATER RESOURCES:** flood control, deep draft and inland navigation, locks and dams;

**WATER SUPPLY:** small versus large systems, urban versus rural systems;

**WASTEWATER:** water and wastewater treatment facilities;

**HIGHWAYS:** highways, local roads, streets;

**AIR:** general aviation facilities, commercial passenger facilities, passenger facilities;



MASS TRANSIT: buses, fixed rail;  
HAZARDOUS WASTE: treatment, storage disposal;  
SOLID WASTE: landfills, waste-to-energy plants.

Like Fragile Foundations, this study will analyze these and the many other different investments which fall under the aggregate categories.

### **The Relationship of Infrastructure Investment to the Economy and the Quality of Life: Current State of Research versus Federal Policy Needs**

The literature on public works and the economy is burgeoning, so much so in fact, that there are a number of literature surveys of the field available. There have also been a number of national studies of public works, some of which have already been mentioned above. Thus, an extensive literature survey will not be conducted here. (References are provided alphabetically by author in Appendix C and by topic in Appendix D; citations of literature surveys may be found in the topical bibliography under "Literature Survey").

Instead, this section will report on the applicability of the current state of research to Federal policy needs and, in particular, the extent to which the known and unknown about infrastructure can help determine how much and where to invest Federal resources. As it happens, not much beyond general inferences are widely shared at this point.

### **Untangling Cause and Effect in Public Works and Economic Growth and Productivity**

It is indisputable that public works investment by state, local and Federal governments, measured as a percentage of Gross Domestic Product (GDP), has declined since the 1960's. But there is disagreement about which factors have caused this historic decline, or how this decline affects economic variables such as income and productivity.

There is currently much debate over the cause and effect of infrastructure and the economy. The services which infrastructure provide, such as the improvement in mobility provided by a new bridge, can cause changes in output either by affecting suppliers of goods and services or by affecting total demand for those goods and services (infrastructure demand being one component of that overall demand). Four main channels of causation have been identified.

### **How Public Works Affect Private Economic Activity**

**Causal Effect #1: The services provided by public capital can be a direct input into private production.** The most direct way in which public capital affects private economic activity is by providing services to private producers which are directly used in the production of goods. A water supply facility, for example, may provide water directly to a steel plant.

**Causal Effect #2: The services provided by public capital can affect private output by increasing the productivity of other privately provided inputs.** Public capital may also increase output by creating an environment which indirectly enhances the productivity of other private inputs. In this case, rather than being used directly as an input by a firm, an infrastructure facility may provide services which makes other labor and capital used by the firm more productive and/or less costly. An example is a road which facilitates the commute of firm employees, lessens their commuting time, and makes the workers more productive at work or allows the firm to choose from a wider pool of skilled labor.

**Causal Effect #3: The services and amenities provided by infrastructure can create an environment which draws inputs from other areas.** Infrastructure also affects economic growth by creating an environment attractive to labor and capital from other areas. This attraction of goods and services from other areas generally implies a redistribution of national income from one locale to another, rather than an increase in national income (though if inputs are being attracted from other countries, this may not be the case). Workers and firms may be attracted to a particular region by infrastructure for a number of reasons, ranging from the fact that public facilities may lower the costs of operating in a given area relative to surrounding areas, to the possibility that facilities may increase the amenities and quality of life in a locale relative to others (for example, a refurbished and revitalized canal may create desirable canal-front neighborhoods in which workers and entrepreneurs from other cities want to live).

**Causal Effect #4: The building and maintenance of facilities can create temporary new demands for goods and services, and thus raise the level of economic activity.** The actual construction of a facility results in direct and indirect purchases of goods and services which provide a temporary stimulus to an area. Thus to build a wastewater treatment facility, one needs to buy the services of construction workers, engineers, steel and cement, to name but a few needed inputs, and these purchases provide income and employment directly to suppliers and workers. These workers and suppliers then spend that income on other goods and services not directly related to the construction of the facility itself and these indirect purchases cause further stimulus to economic activity.

The area thus stimulated may only be local if the main effect of a public construction project is to draw resources away from another public or private project. On the other hand, if there are unemployed or underemployed resources in the economy, and it is this set of resources which is actually used to build the project, there may be a temporary stimulus to the national economy.

**Supply and Demand Effects:** The effects described above are classified by economists either as supply or demand effects. Thus infrastructure services can cause changes in output either by affecting suppliers of private goods and services or by affecting total demand for those goods and services (infrastructure demand being one component of that overall demand). The



first three effects described above are supply effects; the last is a demand effect and is the type of stimulus that much of the infrastructure debate often focuses on namely, the increase in jobs caused by the purchases of labor and capital to build a new facility.<sup>5</sup>

**The Distinction Between Infrastructure's Effects on the Location of Economic Activity and Increasing Overall Economic Activity:** It must be noted that infrastructure services can affect both overall output at the national level and the location of that activity within the Nation. In practice, the distinction between these effects is often difficult to make since the locations of economic activity usually shift along with any changes in national output. Nonetheless, it must be kept in mind that many of the causal relationships described have both locational and national dimensions to them.

### **Is America Currently Underinvesting in Infrastructure? Two Contrasting Views**

Public infrastructure investment can lead as well as follow economic development. The causal factors described above are instances where infrastructure "causes" or leads to a change in economic activity.

However, causality can run the other way. In other words, growth in income or output in a given area might occur first and then lead to an increase in demand for public works investments either because such projects are desired to address problems and needs caused by economic growth or because, as per capita income rises, more consumption of "public goods" such as a new monorail to replace an aging bus line, is desired. Economists generally agree that infrastructure is both a cause and effect of economic activity, but disagree about how much and in what circumstances it is one, the other, or both.<sup>6</sup>

Some economists and policy analysts believe that infrastructure, at present levels of investment, are a positive impetus to economic growth and productivity, and that more public investment is needed to increase that growth and productivity to prior levels. Thus the decline in public infrastructure investment is viewed as a cause of the historic decline in national productivity.<sup>7</sup>

On the other side are analysts who maintain that infrastructure spending is basically demand-driven, that during the 1950's and 1960's, demographic and income changes led to a demand for more infrastructure, relative to national output, and that the waning of those changes has led to the current relative decline in public infrastructure investment.<sup>8</sup> Added in to this mix are voices, on both sides of the debate, that emphasize the need to carefully choose infrastructure investments based on the consistent application of economic efficiency criteria, and point out existing inefficiencies in managing and pricing the current public capital stock.

## **General Conclusions of Existing Research: Infrastructure Matters**

How much truth do each of these stories contain? In general, there is agreement that the services provided by infrastructure, broadly defined to include all types of public works, do have a positive effect on measured output. Thus, whatever representation of output is being studied - national output, gross state product, manufacturing output, personal income, manufacturing value-added, total factor productivity (TFP) - most studies have found that more public capital is associated with higher levels of that output. Empirical results also generally show that infrastructure's positive impact on production is greatest at the national level. As the level of analysis gets more specific (e.g. from Nation to region to state to city), the positive effects of infrastructure on output appear to become smaller, perhaps because the impacts become increasingly difficult to detect, possibly because of leakages of impact from the smaller area under study to a larger area.

### **Caveats to This General Conclusion**

While research thus far generally confirms that infrastructure has a positive effect on economic output, it may not always have a positive effect. The following points should be kept in mind when examining the economic impacts of public works:

**1. While most estimates confirm infrastructure's positive effect on economic activity, a few estimates do not.** Not all estimates of infrastructure's impact on productivity and other economic variables are positive. However, a large majority of these estimates are positive and this preponderance has proved the case to most economists' satisfaction that public works are positively related to economic growth.<sup>9</sup>

**2. There is no consensus on the extent to which infrastructure is a cause or an effect of economic growth since statistical analysis often cannot identify the direction of the cause-effect relationship.** While economists accept the notion that, on average, where there is more infrastructure, there is generally more economic activity, there is not yet a consensus on what circumstances lead to infrastructure investment being a cause rather than an effect of economic activity, or whether public works generally leads or follows economic growth.<sup>10</sup>

**3. Infrastructure affects quality of life as well as the economy, but these effects are difficult to quantify.** Much of the literature has focused on infrastructure's impacts on measurable economic variables. Analysts recognize that public works also have significant effects on quality-of-life measures, such as environmental quality, which are not included in national income accounts. Some even say that these "intangible" benefits (from the point of view of income accountants) are infrastructure's main contribution to society.<sup>11</sup>



**4. Services provided by facilities, rather than the facilities themselves, are what is important to long-run economic growth.** Economists agree that infrastructure facilities by themselves do not generally facilitate economic growth; instead, the services that these facilities offer are key. Thus the mere existence of a bridge does not by itself improve economic performance over the long-run, but the fact that the bridge facilitates travel from one point to another may lead to such an improvement.<sup>12</sup>

**5. Users of infrastructure should be commensurately charged for the services they receive.** The prices of services offered by infrastructure are very important. Theory and empirical studies suggest that many infrastructure services provided by the Federal and other levels of government are underpriced and hence overused. This overuse often ends up resulting in higher maintenance costs for facilities and shorter service lives.<sup>13</sup>

Of course, identifying users and charging them for services rendered may, in some cases, be difficult or costly. In such cases, the costs of collecting user fees must be weighed against the revenues those user fees would yield.

**6. It is possible to invest too much, as well as too little, in public works.** Clearly, there can be too much infrastructure investment. Common sense, theory, and a smattering of empirical studies have shown that overinvestment in public works can and does occur and that in such cases, disinvestment - in effect the abandonment or lowered use of a facility - may be recommended. In general, the literature finds that there are diminishing returns to scale in public works, i.e. that the more public capital there is in place, the lower the rate of return will be on an increment to that capital.<sup>14</sup>

**7. It is cost-effective to properly maintain infrastructure.** It is well established that proper maintenance of public works is essential to minimizing life-time costs and that deferral of such maintenance dramatically increases the costs of infrastructure. It is also clear that many governments are currently underfunding maintenance of their public capital stock.<sup>15</sup>

**8. A positive impact of an infrastructure investment in gross terms can become neutral or negative after the costs of the investment are subtracted out.** Many public works projects will increase output in some way. However, this investment is costly and the resources to fund the investment must be drawn from some other alternative use which may increase output by the same or a greater amount. Thus, although the gross economic impact of an infrastructure project may be positive, one must not assume that the net effect, after accounting for real costs, is similarly positive.<sup>16</sup>

**All inferences are based on the average case and may not apply in particular circumstances.** All of the statements above apply "on average" - that is to say, while the sum of all public works investments may have a positive national impact, particular public works

projects are inherently local and their effects are closely tied to the local circumstances in which they operate. Thus a bridge may have positive effects where there is traffic congestion, while the exact same bridge, placed in the middle of an unpopulated, undeveloped area, may be a highly inefficient investment. Statements about average effects are very useful in formulating broad strategies and narrowing down lists of alternatives but in the end these statements do not obviate the need to consider projects individually on a case-by-case basis.

### **Guidance for Federal Policymakers Based on the Current State of Knowledge**

Thus far, the literature reads more like a list of do's and don't's for Federal policymakers rather than a set of suggestions for drawing up a strategic investment plan. The list reads something like this:

1. Don't automatically assume that your budgets are inadequate;
2. Do better manage the available resources;
3. Do focus on services offered, not facilities;
4. Do consider charging more for services being offered;
5. Do conduct individual economic analyses of projects when the time comes for determining means of meeting specific policy goals.

### **Why is There Relatively So Little Agreed Upon Regarding Infrastructure and What Can Be Done About It?**

General statements about infrastructure's relationship to the economy are so hard to make in part because of the limitations which have faced researchers in this field. The policy implications which can be drawn from the existing literature, particularly for the Federal government, are also often limited. Some of the reasons for the tentative and broad nature of many of the present conclusions about infrastructure's relationship to economic growth, and the accompanying amorphousness of policy guidance which can be inferred, include the following:

**1. The complexity of the problem:** The problem of determining how infrastructure affects the economy, and the larger society as well, is inherently complex. General statements are difficult to make because of the multiplicity of influences on the economy and the complexity of the workings of the economy itself.

Moreover, general statements about public works often cannot be directly applied in specific situations, since every situation in which a public investment might be placed is different from every other situation, at least in subtle respects. Local characteristics which are recognized as being important in determining the efficacy of public works as an economic development tool include the existing supply and quality of local capital and labor (e.g. the extent to which there





is an educated labor force in place); the supply, age, and quality of other local infrastructure (e.g. the extent to which basic sewer, water, and transport systems are already in place and functioning); local development and traffic patterns (e.g. whether roads are congested or development dispersed); the state of the social fabric (e.g. the relative safety of the community, public health and so on); the type of infrastructure being put in place (the literature thus far indicates "core" capital, such as transportation, has the biggest impact, water and sewers less, and others none; but there is not enough evidence yet for a consensus on this point); and the list goes on.<sup>17</sup>

**2. Study Inconsistencies:** Although the literature has focused on infrastructure's effect on output, the studies themselves have focused on different aspects of the problem. For example, studies have examined the Nation, the states, regions, and cities and have used different time periods. Also, the actual output variables which have been tested have differed substantially across studies: measures which have been used include manufacturing value-added, personal income, gross state product and total factor productivity. Some of these measures, particularly net rather than gross output measures such as value-added, pose certain theoretical problems and problems of interpretation. The fact that infrastructure's impact on output has generally been found to be positive across this wide range of measures of different types of output across time and space has increased confidence that public capital matters, but it has also made it nearly impossible to make firm inferences about the effects which public capital may have on specific policy variables of interest.<sup>18</sup>

**3. Data Limitations:** The data used in many studies are often problematic. Classifications of investments in public physical capital, maintained by government statistical agencies, are sometimes too limited, contain expenditures which are extraneous to the purpose at hand, and are usually restricted to publicly provided infrastructure, even if identical infrastructure is being offered by the private sector. These data are also primarily national estimates of capital stock at the local level have first generally been converted into national stocks from flow information at the national level and then disaggregated using imputations based on national ratios or rules-of-thumb. Of course most of this information is in terms of dollar values of physical assets. Relatively little data is available on types, quality, and conditions of the assets themselves nor on the types, quality, and nature of the services these assets make possible.<sup>19</sup>

**4. Differing Models, Different Data, and the Difficulty of Comparing Results:** A wide variety of models has been used and little in the way of controlled comparison has been done. The wide variety of data has been set upon by an equally wide variety of models, including production functions, cost functions, and profit functions, each of which produce different estimates with different interpretations. The models themselves are sometimes *ad hoc*, or contain problematic simplifying assumptions, or assume a particular type or direction of causality with respect to infrastructure and economic growth, even though causal questions are one of the questions the studies are attempting to answer. Here, as with the data, it can be difficult to

know how much different results produced by different studies can be attributed partly to differences in methodology.<sup>20</sup>

**5. Econometric Problems:** There can be substantial difficulties in actually estimating these models. The econometric difficulties have been greatest in measuring, testing, and interpreting statistical relationships accurately. To give but one example, the strength of the measured relationship between output and infrastructure has been affected greatly by whether one uses levels of infrastructure in a given year or net changes from a level in one year to a level in the next. Which figures are appropriate is a matter of one of the many debates in this area.<sup>21</sup>

**6. A Lack of Focus on Policy Questions:** With a few exceptions, much of the literature which has been getting the attention has been written by academic economists for economic audiences. Usually the data used are public-use and there tends to be little reliance on, or even awareness of Federal work. Moreover, while the work has policy ramifications, it does not often explicitly (or implicitly) ask policy questions such as "How will this set of specific public capital programs affect this set of economic variables in that local area?"

**7. A Lack of Focus on System-Wide Performance:** Almost paradoxically, while much of the analysis done thus far is highly aggregated, it lacks a systematic view of the infrastructure network. Widely different modal investments are often added up like so many apples and oranges. Even where investment types are broken out, they are analyzed as purely separate components as if none of the other programs existed. A few of the national studies, such as Fragile Foundations, have attempted to take a systematic view, but have usually stopped at generalities. Much work remains to be done.

### Significant Challenges

All of this is not to impugn the work which has been done thus far. Any work on this topic, including this study, faces these same challenges. Much has been learned over the years; indeed, as general as many of the statements above seem, most were not agreed upon ten or fifteen years ago. Moreover, the complexity of the problem argues for a multiplicity of approaches. But at the same time, there are changes in study design and objectives which are suggested by the debate thus far and which this study is committed to implement. How much these changes will result in improved understanding is, of course, something that the study's outcome will reveal.

The current state of knowledge and the limitations of that knowledge which have been reviewed above can be summed up in the following table:



**TABLE 1: INFRASTRUCTURE'S IMPACT ON ECONOMIC ACTIVITY**

General Conclusion:

Infrastructure Matters

How Infrastructure Matters:

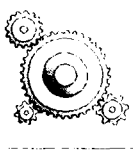
- \*As an input into production;
- \*by enhancing productivity of other inputs;
- \*by attracting inputs from elsewhere;
- \*by providing demand for construction and other services;
- \*by responding to demographic and structural changes.

Caveats to These Insights:

- \*Services, not structures, are important;
- \*services should be appropriately priced;
- \*there can be too much as well as too little investment;
- \*facilities must be properly maintained;
- \*new investments must be carefully analyzed, case by case.

Reasons That Not More is Known:

- \*Complexity of the problem;
- \*inconsistencies in what current studies measure;
- \*lack of comparability across methods and data;
- \*limitations in data themselves;
- \*econometric and estimation problems;
- \*lack of policy focus in current studies;
- \*lack of focus on system-wide performance.



## **PROCESS**

### **Developing a Scope of Work**

To develop a scope of work which avoided or mitigated at least some of the difficulties cited above and to encourage an interagency effort, the Corps determined that it was first necessary to convene several workshops to frame issues and get agencies sharing their knowledge and perspectives.

### **Participation**

To examine the infrastructure debate more fully, three one-day workshops were held on July 16, September 17, and November 6, 1992 and were attended by staff from the following Federal agencies:

- U.S. Department of the Army, including the Corps of Engineers
- U.S. Department of Agriculture
- U.S. Department of Commerce: Bureau of Economic Analysis
- U.S. Department of Energy
- U.S. Environmental Protection Agency
- U.S. Department of the Interior: Bureau of Reclamation
- U.S. Department of Transportation:
  - Federal Aviation Administration,
  - Federal Highway Administration,
  - Federal Railroad Administration, and
  - Federal Transit Administration
- U.S. Office of Management and Budget

Representatives from the Congressional Budget Office, Congressional Research Service, Federal Reserve Banks of Boston and Cleveland and various academic institutions also attended. (An attendee list and a condensed paraphrase proceedings of the three workshops is contained in Appendix B).



## Preliminary Findings Regarding Study Means and Ends

**General Problems and Needs Defined:** Workshop participants struggled with a number of issues regarding appropriate study design, focus and so forth. However, at the end of the three workshops, some general propositions about research needs and limitations became clear.

**1. There is no need for further publication of literature surveys.** The growing literature on public capital has spawned a growing number of surveys of that literature. These surveys are useful, but there is no need for another one. Rather these surveys should be built upon with new information and original research.

**2. Economic theory alone cannot provide answers to the questions of how and how much public capital matters.** Economists have been guided by their theories to investigate particular aspects of the infrastructure problem more intensively. Theory suggests, for example, that users are not charged enough for much of the public capital they use and that better pricing will have high payoffs. Theory also suggests that proper levels of maintenance will have high rates of return. Some evidence has been gathered showing these rather common-sense propositions to be true.

However, while existing public capital stock can be better managed, theory provides less guidance about what parts of that stock should be added to, what parts should be abandoned, and in what ways these increments and decrements should be undertaken. Where theory does provide some guidance, the limited evidence often raises questions rather than confirmations. For example, Alicia Munnell has pointed out that public capital should not have greater impacts on **measured** output than private capital does and yet some studies show precisely this result.<sup>22</sup> Is theory incomplete, the empirical studies misleading, or is there something else being missed? Available evidence has reached its limits in providing answers. New evidence, and analysis of that evidence, is needed.

**3. The Federal government could use some directed research to address the question of where best to invest public capital.** The Federal government spends substantial sums on non-military public capital every year. Existing literature provides almost no guidance on how to allocate this money. Federal agencies have conducted some original research on their own, but little comprehensive, systematic, or inter-program work has been done. The need for such work is clear.

These conclusions led to the decision to think broadly and aim high, realizing that while all the goals might not be fully reached, this effort will serve as important new work.



- ▶ **Be Original:** Collect new data, or bring previously unused or internally used information, into the public domain;
- ▶ **Be Comprehensive:** Within limits, of course, look at Federal infrastructure programs comprehensively. Consider infrastructure as a network, cutting across programs, as well as looking at the components of that network.
- ▶ **Be Policy-Oriented:** Ask questions specifically about Federal monies which the Federal government can later use to make investment decisions - hence the focus of this study on Federal expenditures and how these expenditures affect, and are affected by, economic structure.

### General Issues of Debate

Stating goals such as those above is far easier than developing specific means for achieving them. Not surprisingly, the same sorts of divisions existing among academic economists existed among government economists. Perhaps more surprisingly, some common ground on goals and methods for attaining those goals was reached, resulting in a final workplan (contained in Appendix 2). The debates focused on a number of issues, including:

1. questions the study should ask (including the definition of infrastructure and the impacts to be studied);
2. methods and models which the study should employ;
3. data which the study should use.

**Study Questions:** When first discussing what questions the study should ask, a wide range of questions were suggested. In fact, one of the first requests of workshop participants was that an inventory of such questions be drawn up and that rankings be made of that inventory. In the end, participants identified three main questions which the study should focus on:

- ▶ How should public capital investment strategies change as the structure of the economy shifts, and how is that structure and infrastructure related?
- ▶ What are the spillover, external economy, and network effects of public capital (containing subsidiary questions such as how public capital affects different industries and regions and what environmental and social impacts occur because of public capital)?



- How should Federal resources be allocated among competing needs - in other words where should the Federal government invest its resources?

**Definition of Infrastructure:** As for the definition of infrastructure, the Corps of Engineers originally started with the categories used in the NCPWI study Fragile Foundations which included:

Water: water resources, water supply, wastewater;

Transportation: highways, air, mass transit, intermodal;

Waste Management: hazardous, solid.

A spirited discussion ensued about whether this definition was too narrow. The general consensus was that the answer was "yes". However, it was also felt that, for the sake of keeping the study manageable, these categories, while not perfect, would serve as a reasonable starting point.

**Alternative Ways of Defining Infrastructure Modes:** There was also much discussion of alternative ways of analyzing the Fragile Foundations modes, for example, by dividing transportation along service types such as intercity and intracity travel rather than sub-modes. The general agreement was that experimentation with alternative classifications would be useful in developing the study and their use in the final study products would be developed as the study progressed.

**Time Period for Analysis:** There was also discussion of the time period which the study should cover. Most involved agreed that the suggested focus on Federal investments over the next five years was acceptable, but that the impacts to be analyzed were medium- and long-term, with the long-term lasting at least as long as the lives of the assets being analyzed.

**Non-Economic Impacts:** It was recognized that infrastructure has a wide range of impacts on the quality of life beyond economic growth and productivity effects. By their nature, these impacts, such as air or water quality, aesthetic value of facilities, ability to reach recreational, pristine or exotic areas in less time, reduced commuting times, and so on, are difficult or impossible to quantify. While there is a vast and burgeoning literature on environmental benefits in particular, these intangibles have interestingly been left out of much of the current debate about infrastructure. Although the focus of this project, like this debate, is primarily economic, it was agreed that there should be an attempt to integrate these effects into the analysis up-front and to conduct some research to better understand how these effects operate.

**Need For a Controlled Comparison:** Methods and models were another area of sharp debate. Most everyone agreed that models were means to an end and that different tasks often required different approaches, often more than one. At the same time, there was a recognition



that much of the current debate had gotten mired in the difficulty of interpreting and comparing results of differing models run on differing data sets.

Thus, a controlled comparison between models run on a comparable data set was felt to be a useful exercise. To keep the matter simple, this comparison would be restricted to two models - a production function approach and a generalized benefit-cost analysis, both done at a fairly aggregated level, such as program investments (e.g. inland waterways)

**Retrospective versus Prospective Analysis:** Another debate arose over whether most of the effort should be devoted to analyzing and estimating past relationships and impacts of infrastructure or instead whether it should confine itself largely to simulating and predicting future impacts. In the end, it was agreed that much of the work, by its nature, would be devoted to analyzing the past since that is the only empirical way of understanding and verifying causal relationships but that the most systematic analysis and the core of the project would be devoted to using this knowledge of the past to predict future impacts.

**Need for Better and More Original Data:** Finally, there was universal dissatisfaction with the state of Federal infrastructure data. Indeed, some participants felt that the most value to be gained from the study was to amass a more detailed and comprehensive data set on currently planned Federal infrastructure investments and on the state of the current Federal capital stock. It was recognized that data collection was the first and most important order of business and also that it would take the most time. The advantages of an interagency effort in rounding up data were apparent.

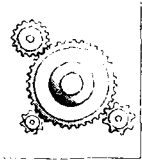
### **The Current Effort**

The result of the workshops was to forge a workplan which was perceived to be credible, doable, relevant to Federal policymaking needs and, perhaps most important, likely to result in some advance from the current state of knowledge.

The goal of the study is a comprehensive treatment of Federal infrastructure within certain predefined boundaries. Promising leads uncovered by this initial treatment will be pursued using additional data analysis and case studies. It was agreed that enough literature reviews had been done and that the relationships identified using economic theory alone had already been well-covered. A comprehensive treatment, and uncovering of original data, had not been done yet to any great degree and held the promise of more rewards in terms of new knowledge.







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## **PRODUCT**

### **Overview of the Workplan**

The detailed scope of work developed as result of the three workshops is contained in Appendix B. Conceptually, the work can be said to consist of four sets of tasks, each of which are designed to deal with some of the challenges faced in prior research which has kept guidance to Federal policymakers fairly limited. These four sets of tasks, each of which will be expanded and fleshed out later using case studies and additional analysis, are:

1. Organization of an analytic framework
2. Data collection
3. Comparison
4. Simulation

**1. Organization of an Analytic Framework:** To meet the challenge of conducting a comprehensive analysis of the economic and non-economic impacts of the Federal infrastructure system, the study will begin by developing an overall framework to account for all costs and benefits, broadly defined, of Federal infrastructure investment. This framework will serve as a shell, to be filled in as the study progresses, which integrates economic and non-economic impacts of public works into a single conceptual view of the world.

**2. Data Collection:** The study seeks to improve understanding of the potential rates of return to potential future infrastructure investments. To even begin to reach this goal, one must have high quality data regarding appropriate and relevant phenomena. Given the interagency nature of this effort, it is hoped that there will be uncovered either new or previously unpublished data regarding current and planned investments in Federal infrastructure programs and the nature, quantity, and quality of services offered by existing Federal capital stock.

**3. Comparison:** An oversimplification of the infrastructure debate thus far might pit cost-benefit approaches on one side, favoring no new large-scale increases in public capital investment, and production function approaches on the other side, favoring such large increases.



This characterization is, of course, unfair, but it is true that much of the uncertainty surrounding the size of the economic impact of public works expenditures may be due to methodologies.

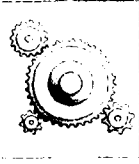
To untangle some of these issues, the core of the effort is a controlled comparison, on comparable data, between broad benefit-cost analyses of investments in infrastructure modes and production or cost function analyses of the same investments. (Benefit-cost analysis is here defined as the quantification and classification of some investment impacts as costs to society and others as benefits, using specified criteria such as willingness-to-pay, and then netting out the difference between the two to determine whether the investment impacts represent a net gain or loss to society). Analysis of economic impacts will start at the national level, and additional analysis at regional, state and local levels, and by more detailed expenditure category is desired, but may not be accomplished depending on time and resources and data constraints.

**4. Simulations:** Already mentioned is that fact that this study aims to be relevant to policymakers, particularly at the Federal level. One way ensuring this relevance is to focus on Federal programs. Another way is to simulate the economic impacts of planned Federal infrastructure investments in the future, doing a with/without analysis. Future projects will be evaluated using prospective simulations of both benefit-cost and production function analysis.

Of course, to understand the future, one must understand the past. Retrospective analysis is a key part of the study, and the impacts of past investments on past economic performance will be assessed to better understand economic dynamics, potential causal relationships, and the workings of different analytic models. However, the main output of this study will be a simulation of future economic impacts of current and future Federal infrastructure investments.

### **Aspirations Versus Outcomes**

As written, this effort is ambitious. Given the difficulty of data collection and methods improvement, it is expected that most of the study effort will be consumed with the means rather than the end, but participants agreed that even if the goal was not reached, it is worth the attempt, and that whatever work was done would serve as a foundation which new efforts led by other entities could build off of.



## **ORGANIZATION**

### **Execution of the Effort**

To make sure the work gets done in a timely fashion and that it is consistently of high quality and policy-relevance, a structure has been set up to guide the effort. This structure consists of a set of review committees and a contracting structure incorporating the use of unbiased and skilled expertise.

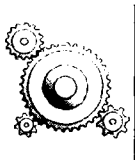
**Oversight Committees:** A number of oversight committees have been established for quality control and transmission of a vision from participating agencies. There are three such committees:

1. **Management Committee** - composed of individuals from participating agencies, this committee will make decisions, on the agencies' behalf, regarding the direction of the study, its scope, its focus, and the deployment of resources committed to it. This committee will designate a project manager from one of the agencies with full-time responsibility for managing the effort and acting as the main point-of-contact between the committee and contractors.
2. **Technical Committee** - composed of individuals from participating agencies and others with expertise in the modes and infrastructure programs being studied, and technical details of the data, models and theory underlying the project, the main task of this committee will be to ensure that the technical work being done meets the objectives at hand. At least some members of the committee have had direct experience working with the models being used by the contractors and have had direct experience working with the relevant data.
3. **Convening Group** - composed of individuals who attended the first three workshops and aided in designing the original scope of work, this group will remain in place to meet periodically to review the work in progress and the final reports, bringing to bear on the work a continuity and overarching perspective.



**Experts:** Apogee Research, Inc., has been chosen as the lead contractor in this effort. (Apogee was hired to conduct many of the technical studies which the National Council on Public Works Improvement used to produce Fragile Foundations, and Apogee also wrote sections of that final report.) Several subcontractors will be doing much of conceptual work in terms of choosing and evaluating models and posing questions for analysis. There will be two classes of subcontractors. The process calls for core production function analysis and core benefit-cost analysis. These two efforts will each be led by neutral, experienced, well-respected people in their fields with relevant expertise, who will be doing most of the conceptualization of the problems and will select specific economic models to operationalize the approaches.

As these coordinating experts guide the work and issue orders, people who have developed models, such as David Aschauer and others, will be consulted and provide input to the process and others, such as Apogee staff, will do much of the technical work, using the guidance of these outside experts.



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## CONCLUSION

### Next Steps

The workshops have ended and the real work of the effort is beginning. This report serves both as a description and an announcement of this study. It is anticipated that this work will take place over the next two years and will consist of the following products:

A report describing current and planned Federal infrastructure programs, which will take the data collected from Federal agencies and describe and quantify current Federal public works investment plans. **To be issued 1993.**

A report describing work in progress serving as a status report on the effort, revealing what has been uncovered, what remains to be examined, and how. **To be issued 1993.**

A report on the simulation of economic effects of Federal infrastructure, which will describe the way in which simulations have been undertaken and preliminary results of these simulations. **To be issued 1993/1994.**

Reports on the various extensions of the analysis, case studies, and a synthesis report; all issued over the course of **1994.**

Federal managers always face infrastructure investment decisions and of necessity cannot wait for the results of any study, least of all from a modest effort such as this, before making those decisions. But because there is always a need to decide on, as President Clinton's A Vision of Change for America puts it, "the difficult and often unglamorous steps necessary to ensure prosperity over the long run," it is hoped that the products of this study, as they are completed, will be relevant and useful, and a contribution to an ever-widening body of knowledge about infrastructure.



## Endnotes

1. pp. xv-xvi, in CBO, 1991.
2. See Aschauer, 1989a, 1989b.
3. For example, see Aaron, 1990; Holtz-Eakin, 1988a, 1991; Hulten & Peterson, 1984; and Jorgenson, 1988.
4. Budget of the U.S. Government, FY93.
5. This discussion of causal factors, and much of what follows below, is inspired by Eberts, 1991.
6. Theoretical discussions can be found in Bergstrom and Goodman, 1973; Borchering and Deacon, 1972; and Pestieau, 1976.
7. Aschauer (1990a, 1990b, 1990c, 1989a, 1989b, 1988b) has been a leading proponent for this view.
8. This is the story told, for example, by Hulten and Peterson, 1984.
9. See McGuire and Nienhaus, 1992, for a discussion.
10. For a survey of the literature, see Eberts, 1991 and 1990. For other discussions, see Bell and Feitelson, 1990; Garcia-Mila, 1987; Hansen, 1965; Hirschman, 1958; Holtz-Eakin, 1988a; Hulten and Schwab, 1984b; Looney and Frederiksen, 1981; Sahni and Singh, 1984; and Singh and Sahni, 1984.
11. Some discussion of these issues can be found in McDowell and Bell, 1991; National Council on Public Works Improvement, 1988; and U.S. House of Representatives, 1991a.
12. This is a key finding of the National Council on Public Works Improvement, 1988.
13. Most noteworthy in this field are studies by the Congressional Budget Office, 1992b; Small, Winston and Evans, 1989; and Winston, 1991.
14. For example, Aberg, 1981; Antle, 1983; and Carlino, 1979.
15. National Council on Public Works Improvement, 1988; Office of Technology Assessment, 1990.
16. See, for example, CBO, 1991.
17. Fox, 1990 and Fox and Smith, 1990, discuss many of these issues.

18. The literature survey by McGuire and Nienhaus, 1992, contains a more detailed discussion of these issues.
19. See McGuire and Nienhaus, 1992.
20. See McGuire and Nienhaus, 1992.
21. There are many attacks in particular on the production function methodology specifically, and the observed correlation between productivity and infrastructure spending more generally. See Aaron, 1990; Congressional Budget Office, 1991; and Jorgenson, 1988, for examples.
22. Munnell, 1992.



## **APPENDIX A: SCOPE OF WORK**





## APPENDIX A

### SCOPE OF WORK

#### Background

During the 1980's, a number of reports came out detailing the problems with America's infrastructure. The broad consensus of these reports was that there was underinvestment in the Nation's public works. There was far less agreement about the magnitude of that underinvestment or about where funds should be allocated.

Late in the same decade, a debate began to rage in the academic community about the role of infrastructure investments in the performance of the United States economy. Some economists found that new public works generally have high rates of return, using a methodology of estimating an aggregate production function for the national economy; other economists, relying more heavily on traditional benefit-cost analysis, found much lower rates of return for public capital investments.

In absolute terms, Federal infrastructure investments are sizeable; direct Federal expenditures for physical capital in non-defense programs equalled over \$20 billion in 1992; Federal grants for capital spending in non-defense programs equalled over \$27 billion in the same year.<sup>1</sup> A more definitive assessment of the impact of that spending on the American economy is in order.

#### Purpose

The purpose of this study is to assess the total rate of return on planned Federally provided and leveraged capital spending and capital stock in selected categories of infrastructure; understand the effects that these investments may have on economic activity; and examine and compare a number of methodologies for assessing this impact.

#### Definitions and Study Scope

For purposes of this study **total** refers to effects which go beyond those which are private and beneficiary-specific to include phenomena such as network and linkage effects; more broadly speaking, total includes both economic and noneconomic returns. **Rate of return** refers to the

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<sup>1</sup>. These figures are estimates obtained from Table 9.1 of the Budget of the United States Government: Fiscal Year 1992.



**net** effects of infrastructure investments of different types, focusing on long-run effects (with the long-run being defined by the economic and operational life of capital stock being analyzed) but not excluding short-run effects. The impacts which will be analyzed include:

- \* Factor impacts (e.g. labor [or capital] incomes, productivity, etc.);
- \* Sectoral/Industry impacts (e.g. industry x's income, productivity, etc.);
- \* National income;
- \* Non-economic impacts (e.g. environmental effects).

**Planned Federally provided or leveraged** refers to programs likely to exist at the Federal level over the next five to seven years where there is a significant Federal interest and involvement in terms of providing direct infrastructure facilities and services, grant money, loans, guarantees or other sources of liquidity.

To keep the study manageable, some arbitrary lines have to be drawn. Thus where the Federal government's role is primarily regulatory and its direct and indirect funding responsibilities are negligible, the program will not be studied.

However, the services (as opposed to the programs) which will be examined are not necessarily or always primarily Federal. In many cases, Federal investments fit into a larger infrastructure system which is primarily non-Federally owned or operated. In such cases, the Federal program could not be studied meaningfully without considering its place in the larger network. An example would be the role of Federal highways in the national system of state, local, and private roads.

**Selected categories of infrastructure** refers to the eight categories identified in Fragile Foundations. These eight categories are:<sup>2</sup>

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<sup>2</sup>. The aggregate Fragile Foundations categories include analysis of a multiplicity of investments. For example, the investments analyzed under the rubric of the broader classifications include, but are not limited to: WATER RESOURCES: flood control, navigation, dams, locks and dams; WATER SUPPLY: small versus large systems, urban versus rural systems; WASTEWATER: sewage treatment facilities, nonpoint controls, groundwater contamination; HIGHWAYS: interstate highways, local roads, streets; AIR: general aviation facilities, commercial passenger facilities, passenger facilities; MASS TRANSIT: buses, fixed rail; HAZARDOUS WASTE: treatment, storage, disposal; SOLID WASTE: landfills, waste-to-energy plants.

WATER	water resources water supply wastewater
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TRANSPORTATION	highways air mass transit intermodal
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WASTE MANAGEMENT	hazardous solid
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*Note that while these 8 categories are the subject of study, they will not necessarily be the focus of analysis or the categories used to organize the outputs of the study. For example, analysis of the data on transportation could be organized along the lines which the U.S. Department of Transportation used to develop the National Transportation Policy (NTP). In this case, the relevant transportation categories would be:*

TRANSPORTATION	intercity freight intercity passenger urban/suburban mobility international mobility manpower & technology
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The research reports produced could be organized along similar lines or, conceivably there could be two sets of analysis or reports, with one organized along the Fragile Foundations categories and another organized along NTP categories. Different lines of analysis could also be devised for waste and water as well.

### **Outline of Work to Be Done**

The work will proceed as follows:

1. A thorough and complete time-series of Federal infrastructure capital flows and stocks will be collected.

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Like Fragile Foundations, this study will analyze the many different investments which fall under the aggregate categories.



2. Initial assumptions, methods, and specifications for the analysis to follow will be developed and made explicit (e.g. the framework for categorizing investment impacts as costs and benefits, simplifying assumptions used to make the analysis manageable, specification and development of the two different methodologies to be used, namely a generalized benefit-cost and production function analysis, and modifications necessary to make the results of the two analyses comparable).
3. The production function and benefit-cost models will be run on the same or similar data, using the analytic framework developed under item 2.
4. Once the models have been run, the results will be compared; differences and convergences in effects predicted will be identified and analyzed.
5. Then the results of these two analyses will be extended, using other complementary models such as input-output analysis and macro-econometric modelling, to develop estimates of sectoral impacts. Non-economic impacts and causal relationships will be explored in greater detail through case studies.

## **Tasks**

### **I. DATA**

#### **Task 1: Categorize Information to be Collected**

Identify all relevant public and private programs and investments which fall into the categories (and subcategories therein) of transportation, waste, and water. Distinguish between those investments which are Federal, Federally leveraged or key to studying Federal program impacts, and those investments, public and private, which are non-Federal. Then determine program conditions such as investment and O&M cost sharing between Federal, state, local and nongovernmental entities.

#### **Task 2: Collect and Develop Data**

Develop and/or collect relevant program data including, but not limited to:

- \* Overall expenditures;
- \* Capital items purchased each year;
- \* Characteristics of items purchased (e.g. quality, useful lives, service lives, function);
- \* Amount spent on O&M versus new capital;
- \* Characteristics of O&M expenditures;

- \* Characteristics of infrastructure users/clientele;
- \* Characteristics of facility performance;
- \* Prices (explicit and implicit); and
- \* Characteristics and quality of services offered.

These data will be disaggregated in various ways including by level of government (Federal and nonfederal) and geographic location (national, regional, State). Where relevant data do not exist, or are too time-consuming or difficult to collect, reasonable imputations may be made. These imputations must be fully explained, defended, and documented.

### **Task 3: Relate Capital Stocks and Flows**

Develop and/or collect relevant capital stock information and relate the capital flow data to the capital stock data. Where data are plentiful, this task may be as straightforward as checking an outstanding inventory and netting out recorded depreciation. More likely, some imputations and estimates will have to be made.

### **Task 4: Organize Data Collected**

Classify and categorize the information collected by the Fragile Foundation categories listed in the "Definitions" section and also describe how the programs are related to each other in terms of a network. Also classify and categorize information collected according to other relevant categories such as those used in formulating the National Transportation Policy (NTP). Provide cross-references in the data between the Fragile Foundations categories and the other categories selected.

## **II. MODELLING**

### *II.a. Preparations for Analysis*

### **Task 5: Classify Investments to be Analyzed**

Develop and prepare methods for aggregating projects into modal investments, to be analyzed as a large project (or set of large projects). For example, the National Highway System, or the Missouri River lock and dam system, could be considered a project for study purposes

### **Task 6: Conduct a Literature Survey on Potential Benefits and Costs**

Conduct a literature survey identifying types and ranges of dollar values for various costs and benefits, and discount rates, and develop (and defend) a set of "consensus" values.



### **Task 7: Develop a Framework for Analysis**

Specify the likely categories of economic and non-economic impacts and organize an accounting framework for tabulating, comparing, and analyzing these impacts as costs and benefits (and for calculating social rates of return) as these estimates are produced.

### **Task 8: Specify the Baseline and Counter-Factual**

Specify fully the comparison to be done. In particular, clearly specify the baseline case (that is, the situation which would exist with a given set of policies in place) and the counter-factual (the situation which would exist with a change in that set of policies). In detailing the counter-factual, some assumptions must be made that Federal funding for infrastructure diverts resources from elsewhere in the economy (either from the private economy through higher taxes or debt or from other Federal spending). In detailing the baseline, some assumptions must be made regarding provision of infrastructure in the absence of Federal funding (for example, some private toll roads or state funding would be offered if Federal roads were not built). Obviously these are problematic issues and, in many cases, the need for simplicity may override a desire for realism in assumptions. Whatever assumptions are made, there must be a full discussion of the relevant issues.

### *II.b. Simulations*

**Task 9:** Simulate effects of potential public works investments; select production/cost function and benefit-cost models.

Having specified the baseline and simplifying assumptions, a with-without comparison will be made for Federal programs from 1992 to 1997. Thus a forecast will be made using two scenarios: a forecast of economic conditions with a given set of Federal infrastructure investments in place and a forecast of those conditions without those investments. Note that while the comparison would be made only between the presence and absence of Federal programs for the next five years, the economic effects of this simulation would extend as far into the future as necessary. The time frame for analysis may vary depending upon the project in question.

The first step in conducting simulations will be to select and/or modify specific benefit-cost and production and/or cost function models. To assess which models are best suited to the task at hand and to make modifications which improve the performance of the models, it will be necessary to conduct some limited simulations of selected public investments for past time periods, compare the results with actual historic performance, and then make any necessary changes to the methodologies based on interpretations of the differences between the predicted values and actual values. While these historic simulations will be limited and uncomprehensive,



they are a necessary prelude to the prospective simulations described above and will be fully documented and described as part of the final study reports.

**Then, two separate prospective simulations will be done. A generalized benefit-cost analysis, using the accounting framework done as part of Task 7, will be used to produce one simulation and a production function methodology (or its dual, the cost function) will be used to produce another simulation. As much as possible, the outputs of this production function analysis will be put into the same impact accounting framework.**

These first simulations will be conducted so as to be as comparable as possible. Each model will be run on a core set of identical data (recognizing that one method may also require some additional information which the other method does not), identical simplifying assumptions, and identical units of analysis, (i.e. projects [as defined under Task 5] at the national, or perhaps a set of subnational levels [which taken together constitute the geographic confines of the Nation]).

#### **Task 10: Conduct Sensitivity Analyses**

The simulations above will first be run using "reasonable" parameter values, then conducted again varying important values such as benefits, costs, discount rates, and details of the counterfactual and baseline cases. ("Reasonable" values will be chosen based on the results of the literature survey conducted in task 6 and using expert judgement). There may also be some additional sensitivity analyses run on one method but not the other; for example, the functional form of the production function may be varied.

#### *II.c. Comparison of Simulations*

#### **Task 11: Convert Model Outputs to a Comparable Metric**

The basic outputs of a benefit-cost model are figures for net benefits and rate of return. The basic output of a production function model is an output elasticity. Instances where the results of the simulations based on the two different models are not directly comparable must be identified and then modified so they can be compared. For example, the production function elasticities described above must be converted into rates of return. Also, as mentioned under Task 9 above, the outputs of the 2 models will be put into a common impact accounting framework.

#### **Task 12: Identify Convergences and Similarities Between the Production Function and Benefit-Cost Results**

Results of each of the simulations done above will be tallied and compared; where no comparison is possible (for example, one model generates an output that the other does not) this



fact will be noted. Divergences and convergences will be noted and quantified. As much as possible, there will be an attempt to make statements such as "the rate of return on waterways capital predicted by B/C differs by X% from the rate of return predicted by the production function."

**Task 13: Analyze Convergences and Similarities Between the Production Function and Benefit-Cost Results**

The differences and agreements found between the two models will be analyzed in greater detail with an eye towards assessing why they occurred and what they may mean. This analysis will be guided by an extensive literature search on infrastructure's role in the economy, statistical tests of causality, and other analytic methods and expert judgments.

**NOTE:** In each of the exercises outlined above, there will be an attempt to make the models run on a consistent data set, analyze comparable questions (for example, identical counterfactuals and similar sensitivity analyses) and generate roughly comparable results. The purpose of this exercise is not to set up some sort of contest between models and declare a "winner" (such a declaration would be without real foundation). Rather this sort of controlled comparison will hopefully lead to new insights about the effects of implicit assumptions on research results and indicate instances where there might be synergies, network effects, or other sorts of phenomena which were not anticipated when prior research was done. Indeed, this is just the sort of insight which has been gained as a result of the initial clash of benefit-cost study results and production function results.

### III. EXTENSION OF ANALYSIS

To better understand the implications of the simulations conducted above, explain the real-world dynamics of infrastructure investments, and to add detail to both the benefit-cost and production function approaches, some additional models and case studies will be used.

#### *III.a. Disaggregation of Models*

**Task 14: Extend Benefit-Cost Analysis with Input-Output Analysis**

The estimates of economic impact from the benefit-cost analysis (e.g. changes in input and output supplies) will be used in an input/output model, to be determined later, which will be used to produce a detailed static picture of sectoral and industry impacts. A macro-econometric model, may then be used to extend the static sectoral impact picture into the future. Both the I/O model and the macro-econometric models chosen must be nationally recognized and accepted by the economics profession, have been used in published academic research, and have been cited in the academic literature.





### **Task 15: Extend production function Analysis with Cost Function Analysis**

The results of the production function analysis will be extended using the dual of the production function, the cost function, to generate sectoral impact estimates; the same macro-econometric model may also be used for extending the benefit-cost analysis will also be used for projecting sectoral impacts into the future.

#### *III.b. Causality*

### **Task 16: Describe and Test Causal Relationships**

As in Task 13, statistical methods such as Granger tests will be employed to test for and quantify causal relationships. In addition, at least one case study, perhaps of an industry, will be conducted to flesh out possible causes and effects between modal investments and economic activity.

#### *III.c. Regional and Local Impacts*

### **Task 17: Describe and Test Regional and Local Infrastructure Impacts**

To some extent, the initial simulations may have already quantified subnational impacts, depending on the level of aggregation chosen for analysis. To analyze these impacts more qualitatively and in greater detail, at least one case study of infrastructure investments in a local area will be conducted. A possible candidate for study is a high-technology corridor such as Silicon Valley. If possible, a set of case studies will be randomly selected. In the event that such a random selection is not made, and/or if the number of cases examined is too small to make statistically significant inferences, this fact will be noted and the reader will be advised that the results are purely illustrative of possible causal impacts.

#### *III.d. Non-Economic Impacts*

### **Task 18: Describe and Analyze Environmental and Social Impacts**

All tasks described above are undertaken with the understanding that important impacts of infrastructure on the quality of life and environment must be identified, quantified where possible, and discussed qualitatively otherwise. To emphasize the importance of these impacts, and to better understand their dynamics, at least one case study of the environmental and social impacts of an infrastructure investment will be examined. If possible, a set of case studies will be randomly selected. In the event that such a random selection is not made, and/or if the number of cases examined is too small to make statistically significant inferences, this fact will be noted and the reader will be advised that the results are purely illustrative of possible causal impacts.



### *III.e. Larger Impacts*

**Task 19:** Describe and Analyze the Impacts Beyond the Modes Under Study and Beyond National Borders

The study as written explicitly focuses on eight modes as defined as Fragile Foundations, and on impacts of investments in those modes in the United States. Clearly economic effects do not stop at modal or national borders. The shift from the eight modes mentioned above to NTP categories is an implicit acknowledgement of this fact.

Perhaps using the NTP and other classifications as a starting point, a qualitative and quantitative analysis of international and intermodal impacts will be conducted. An input-output analysis could be used to consider the effects of water, waste management, and transportation investments on industries and modes other than these three (e.g. telecommunications); a macro-econometric model or other analytic model could be used to get a preliminary estimate of international impacts; and a qualitative analysis, literature review, and perhaps a case study (perhaps of a port) could be conducted for a cross-cutting assessment.

## **IV. STUDY PRODUCTS**

As the study progresses, the following reports will be issued:

### **1. Kick-Off Report**

A report announcing the effort, reviewing the literature, describing the findings of the process which led to formulation of the scope of work, detailing the goals of the study and indicating how these goals will be accomplished, to be completed **1993**;

### **2. Data Report**

A data report to be issued after completion of Tasks 1 through 4. The report will describe the data and methods used for collecting and modifying the data, including, but not limited to:

- sources of data
- data elements selected
- criteria used for data selection
- explanation and justification of criteria
- methodology used for adjusting data
- problems existing in the data, both modified and original
- publication of every data record in an appendix



This report will also describe the data systematically, emphasizing the implicit Federal investment strategy inherent in the numbers, the uses to which these numbers will be put in the upcoming study, and the objectives which are hoped to be met at the conclusion of the effort; to be completed **1993**;

### 3. Interim Status Report

A report, for general release, describing the work done thus far, the tasks remaining, and an anticipated outline and structure of the final report; to be completed **1993**.

### 4. Simulation Report

A report describing overall results (perhaps preliminary) of the simulations as outlined in Tasks 5 through 14 above. This report will describe the methods used, conceptual and theoretical framework behind the work, difficulties encountered while doing the work and ways in which those difficulties were resolved and results of the simulations with some preliminary analysis of those results. This report will also detail plans for expanding on the work done thus far; to be completed **1993/1994**.

### 5. Concluding Reports

A series of reports describing the final results of the simulations, their extensions and capabilities; to be completed **1994**.

## V. OVERSIGHT

Several mechanisms for study quality control and management have been instituted to ensure that all participating agencies have a say and that relevant experts can provide input.

### 1. Oversight Committees

a. **Management Committee** composed of individuals from participating agencies who have been given authority to make decisions, on their agency's behalf, regarding the direction of the study, its scope, its focus, and the deployment of resources committed to it. This committee will designate a Project Manager from one of the agencies with full-time responsibility for managing the effort and acting as the main point-of-contact between the committee and contractors.

b. **Technical Committee** composed of individuals from participating agencies and others with expertise in the modes and infrastructure programs being studied and technical details of the data, models and theory underlying the project. The main task of this committee will be to



ensure both a consistent and high level of technical work and to ensure that the right tasks are being done by the right people to meet the objectives at hand. At least some members of the committee must have had direct experience working with the models being used by the contractors and some must have had direct experience working with the relevant data.

This committee may break up into subcommittees (e.g. modal subcommittees or methodological subcommittees) if necessary to concentrate effort and expertise on particular tasks.

c. **Convening Group** composed of individuals who attended the first three workshops. Since the convening group designed the original scope of work, it will remain in place to meet periodically to review the work in progress and the final reports, bringing to bear on the work a continuity and overarching perspective.

## 2. Contracting Structure

The lead contractor will act as an overall manager and coordinator of its own work and that of subcontractors. In addition, this lead contractor will communicate findings and progress to the committees; coordinate inputs, assumptions and outputs of individual research tasks; and assume responsibility for product quality control, and preparation of deliverables. All activities by the contractors and subcontractors will be subject to review by the management and technical committees and final approval by the Corps of Engineers.



**APPENDIX B: INTERPRETATIVE SUMMARIES  
OF THE WORKSHOPS**



## **APPENDIX B**

### **AN INTERPRETATIVE SUMMARY OF A DIALOGUE ON INFRASTRUCTURE ECONOMIC GROWTH, PRODUCTIVITY AND QUALITY OF LIFE AND APPROPRIATE AND USEFUL RESEARCH QUESTIONS**

#### **HIGHLIGHTS OF INTERAGENCY WORKSHOPS**

**HELD ON: JULY 16, 1992**

**SEPTEMBER 17, 1992**

**NOVEMBER 6, 1992**

#### **Foreword:**

To explore issues surrounding the Federal infrastructure investments and economic growth, productivity, and quality of life and to develop a scope of work which addressed questions of relevance to Federal policymakers in a credible and useful way, the U.S. Army Corps of Engineers convened three workshops attended by personnel from Federal agencies, Congressional research organizations, and academic institutions. These workshops were held on July 16, September 17, and November 6, 1992 respectively, each time attended by approximately 30 people.

Panels addressed the first two workshops to stimulate thinking, while the last workshop was purely a working session. In all cases, participants were given a draft scope of work and asked to provide suggestions for revising it. The result of these proceedings was a final plan of work which is currently being executed.

The proceedings contained herein are loose paraphrase and focus on selected exchanges which took place during the workshops. The full proceedings have been taped but have not been transcribed.

Participants included the following people (in alphabetical order):

L. George ANTLE, U.S. Army Corps of Engineers  
David ASCHAUER, Bates College  
Michael BELL, Johns Hopkins University  
Carolyn CANNON, Department of Energy  
M. William CLARK, U.S. Army Corps of Engineers  
Michael DEAN, Office of Water, U.S. Environmental Protection Agency (EPA)  
Michael DEICH, Congressional Budget Office (currently with the National Economic Council)



Alan DICKERSON, Bureau of Reclamation  
Randall EBERTS, Federal Reserve Bank of Cleveland  
Frank EMERSON, Federal Aviation Authority  
William GELSTON, Federal Rail Administration  
Cameron GORDON, U.S. Army Corps of Engineers  
Ann GRAMBSCH, Office of Policy, Planning and Evaluation, EPA  
Thomas HADY, Economic Research Service, Department of Agriculture  
Arthur JACOBY, Federal Highway Administration  
Kurt KARL, The WEFA Group, Inc.  
John KORT, Bureau of Economic Analysis  
John LOVE, Apogee Research, Inc.  
Randolph LYON, Office of Management and Budget  
Al McGARTLAND, Office of Policy, Planning and Evaluation, EPA  
Ronald MOOMAW, University of Oklahoma  
Alicia MUNNELL, Federal Reserve Bank of Boston (current Deputy Assistant Secretary of the  
Treasury for Economic Policy)  
Ishaq NADIRI, New York University  
Robert PIETROWSKY, U.S. Army Corps of Engineers  
Gene PONTILLO, Office of the Comptroller, EPA  
Dennis ROBINSON, U.S. Army Corps of Engineers  
Adam ROSE, Pennsylvania State University  
Kenneth RUBIN, Apogee Research, Inc.  
Kyle SCHILLING, U.S. Army Corps of Engineers  
Norman STARLER, Office of Management and Budget  
Robert STEARNS, Office of Assistant Secretary of the Army (Civil Works)  
Robert WESCOTT, The WEFA Group, Inc.  
Fred WILLIAMS, Federal Transit Administration

## HIGHLIGHTS OF THE JULY 16 1992 WORKSHOP TO DESIGN A SCOPE OF WORK TO STUDY THE ECONOMIC IMPACTS OF FEDERAL PUBLIC WORKS INVESTMENTS

**9:30AM - 10:15AM: Welcome and Introductory Remarks by Dr. Robert Stearns, Deputy Assistant Secretary of the Army (Civil Works) for Project Management**

**Stearns:** Why has everyone been invited to gather at this particular place on this particular day? The Administration and the Congress wanted a dialogue on infrastructure strategy and have given the Corps the task of starting this dialogue. Why was the Corps of Engineers assigned this task? The Corps has engineering expertise; an interdisciplinary staff; a long history of state and local relationships; many local offices; and experience with forging interagency relationships.

The Corps is **not** seeking a new mission or to sell its methods for doing things. Rather the Corps is asking open questions. This scope of work is ambitious.

Reading this strawman scope of work, we see the project represents a very broad study on the effects of infrastructure spending on private growth. The Scope of Work (strawman) lists areas of infrastructure interest: highways, mass transit, aviation, water resources, water supply, wastewater, solid waste, and hazardous waste. The project examines econometric models to analyze infrastructure effects, assess them, and provide answers on what can they tell us.

In accomplishing the task of evaluating the economic value of infrastructure investments, there are eight (8) questions which I think need to be asked:

1. Are we able to define the optimal levels of infrastructure investment?
2. Has the work helped us to determine the priorities of investment within a single agency?
3. Has it helped us to determine how to select among projects in agencies along with the associated tradeoffs?
4. Has it helped us decide whether operations and maintenance, major rehabilitation, or replacement is the best strategy for a given infrastructure, given the facility condition and budget?
5. Has it helped us to develop a common language among Federal agencies on this issue?
6. Does it tell us what data we should be collecting to make informed decisions in the government?





7. What does it say about the appropriate roles of the Federal government, state and local governments, and the private sector in an overall infrastructure investment strategy?
8. If increased public works investments are indicated, how are we going to pay for these investments and who is going to pay? For example, is the beneficiary pays mechanism to be used?

This is what **Federal** research should do, as opposed to purely academic research. I choose to be an optimist and ask everyone to begin with the assumption that this effort is going to work.

### **10:30AM - 11:30 AM: Panel Discussion**

Dr. Stearns then introduced the panel composed of Dr. Alicia Munnell, with the Federal Reserve Bank of Boston; Dr. N. Ishaq Nadiri, from New York University; and Dr. Michael Deich, with the Congressional Budget Office.

#### *I. Presentation of Dr. Alicia Munnell, Federal Reserve Bank of Boston*

**Munnell:** The stock of public capital is huge - around \$2.7 trillion - so it is amazing that the economics profession missed analyzing this factor for so long in examining productivity. A few years ago, Dr. David Aschauer initiated the debate on the effect of public infrastructure investment on private sector output with the publication of his study. His results showed a very impressive effect on output. Dr. Aschauer's work has caused an intense debate on these issues. Skeptics claimed that the study's methodology was flawed. Furthermore, the critics argued that any historical relationship established between public investment and private output does not predict what the effect of future investments would be.

My own work has estimated that a one percent increase in public capital stock increases output by 30 percent. This implies that the marginal productivity of public capital stock is 60 percent. Dr. Aschauer has reported that the GNP increases are greater for public investment than for private investment by a factor between two and five.

Having said this, I do not think that you can tell from what we have whether we need more infrastructure or not, much less what sort of infrastructure we need. Everybody agrees on the sign of the effect of infrastructure on productivity (positive), but there is no general agreement on the magnitude. The computed multipliers for public capital are very large - two to five times that of private capital. But it doesn't make any sense that public capital would have more effect on **measured** output than private capital, since much public investment is for environmental and other social needs not captured in private output measures. New studies have claimed an effect roughly half as large as those found in prior studies.

The critics have three main lines of attack on these studies:

1. Data problems lead to spurious correlations.
2. The wide range of estimates cast doubt on the estimates themselves.
3. Just because one documents a relationship, that does not mean one can make definitive statements about the direction of causality.

With regard to the data, the critics have argued that the regressions should be run on first differences, not levels. Actually, the pertinent question is whether or not the production function represents a co-integrating relationship between output and public capital. Alan Blinder has looked at this question and found that the production function did indeed perform in this way. If this is right, estimation in levels is correct. In any case, you would not expect a rise in public capital in a given year to raise output in **that** year.

With regard to the wide range of estimates, this criticism misses the point. The fact is that all the estimates are generally positive. The newest studies still show positive and significant relationships, with biggest impacts nationally, state impacts half the national impact, and local impacts half of that.

As for causality, it clearly runs both ways (i.e. public capital to productivity and productivity to public capital). My reestimates of state data still show positive effects.

Other critiques are technical, e.g. the lack of input prices in the production function.

Where do we stand? We do know that public capital affects output and growth. However, the production function doesn't answer the questions we have, given the data that we have. We need to improve the data. But in general, even with good information, these approaches will not answer the question of optimal investment levels. Basically you use intuition, look at promising areas, and do careful cost-benefit analysis.

## *II. Remarks of Dr. N. Ishaq Nadiri, New York University*

**Nadiri:** At my center at New York University, we have looked at aggregate impacts and at the effects of public works on firm and industry cost structures. Specifically, we have looked at cost functions at the 2-digit industry level and estimated a cross-section, time-series panel. The cost function contains private sector inputs and public sector inputs as well. Within public sector inputs, infrastructure capital is separated from R & D capital which has been publicly financed.

What have we found?



1. The output elasticity of public capital is much smaller on average than in other studies, but it varies substantially by industry.
2. The public capital elasticity is twice as much as R&D capital in some industries. Again, the effect varies significantly by industry.
3. We are now trying to look at different types of publicly financed capital. There are no definite results yet, but so far we have found that R&D financed capital is non-neutral technically; in some industries it saves capital, in others it does not. Thus public capital reduces costs but does so non-neutrally.

We then calculate the marginal benefits of investment, i.e. how much the private sector would pay for it. This is less than 0.1% in some industries, but again, it varies.

We then calculate spillover effects. We compare the marginal benefits to the marginal costs of social capital. Figuring out marginal cost is no easy matter. We didn't estimate this independently but used Jorgenson's estimate of 1.47. Using this estimate, the social rate of return is around 6% to 8% for public infrastructure, a little higher for publicly financed R&D.

What is the contribution of public capital to total factor productivity? Twenty-five percent to thirty percent of the productivity deceleration is due to the decline in public infrastructure investment and R&D capital declines account for roughly the same amount. If you add the two effects, you find a major impact but again, one which differs by sector.

Of course the scale of effort - returns to scale - is important. Note also that states are not necessarily the relevant units for analysis - they ignore network effects and benefits do not end at the state border.

With this sort of model you can calculate optimal levels of investment; we have not done this yet. The issue of specific projects is not addressed by this approach; that is a matter better addressed by cost-benefit analysis. But cost-benefit analysis will not capture spillover and network effects.

Note one other issue: there are time lags in public capital; it takes time for investments to come on line and there are thus dynamic time and adjustment effects which must be considered.

### *III. Remarks of Dr. Michael Deich, Congressional Budget Office*

**Deich:** This panel marks an evolution in the debate about infrastructure. There has been movement from two camps to a middle ground. It is now clear that public capital matters. It is also clear that the production function approach does not tell you this.

The consensus seems to be that the production function is useful for answering some specific questions. However, cost-benefit analysis is still the best way to go for answering at least 7 of Dr. Stearn's 8 questions.

Alicia Munnell's dismissal of some of the production function critiques are too ready. The fact is, simple detrending methods make the relationship between public capital and output fall apart. We still await the results of more sophisticated methods. (I haven't seen Blinder's work.)

As far as leakages and robustness of results, the studies do show a wide range of effects at the national level. Hulten and Schwab, for one, use regional data and find no significant effects. Leakages are there, but are not a big effect.

Finally, cost functions are promising, but the results are preliminary and not necessarily strong endorsements of more public investment.

Cost-benefit analysis answers the questions you need to answer and interestingly, cost-benefit studies often answer "yes" to the question of "should we invest more". Examples are Clifford Winston's work and some of the Federal Highway Administration's work.

All of the debate about investments is taking place under tight budget constraints, making the use of cost-benefit analysis even more critical. Even if public capital has a big effect on productivity, an aggregate approach can't tell you what investments have the greatest effects.

Finally, the historical evidence is limited. History may overstate future effects since the building of a network has bigger effect than making additions to a public capital stock already in place. On the other hand, history may understate future effects since future technologies like MAGLEV haven't transpired yet.

#### *IV. Panel Question and Answers*

**Nadiri:** Let me make two points. First, this research is all new: don't dismiss it because it is not developing definitive results yet. Second, the analytic approaches are **complements**. Don't move in the direction of one model versus the other. They might serve together to clear up issues of causality.

**Deich:** Throwing out the production function approach is throwing out a lot of valuable results.

**Bell:** All of this underlines the necessity of picking the model to fit the question you're trying to answer. Some models are oriented towards answering some questions, others are better for answering different questions. Thus when you look at location, you look at one set of factors



and at productivity, another set. But you don't include these sets **a priori**; you go by the evidence and the evidence suggests that public capital is important. Thus we continue to test.

**Nadiri:** There is a false dichotomy between the cost-function and the production function. They come from the same source. You have your choice of variables to account for things. For example, a time trend in many ways serves the same role as a population variable. Take your choice - these are not fundamental problems.

I reemphasize that all these techniques are complementary approaches. But there are tough issues, for example, the effects of migration on output, the determinants of migration, etc.

**Deich:** I have another concern. Regression analysis is backwards looking; what does it tell us about what the future should be? Aschauer would say we should invest more, but to me using these past results would be luck of the draw as far as telling us what we'd get if we build more of Project X.

**Aschauer:** I wouldn't say that. I recognize relationships change. What my approach does is to pick up effects that partial equilibrium analysis ignores (e.g. spillovers). Moreover, it indicates a possible magnitude. We interpret this number with caution, but it gives us an outside number perhaps. I agree that the production function and cost-benefit analysis are complementary. But we must ask, just as the production function can be improved, cost-benefit analysis can be improved.

**Jacoby:** For policy purposes, the production function and cost-benefit analysis are both important, but we must figure out where the biggest bang for the buck is in a crude sense and must figure out how our policies affect key variables. These studies show us directions our policies might lead us and that in itself serves a useful purpose.

**Nadiri:** One should not read a huge amount of insight from finding relationships between public capital and productivity. This relationship holds true broadly, but different investments have different effects and assessing these differentials is key.

Also note that the future is always present in historical data - there are always lags. So the sign that historical data show is important (although the magnitude is not).

**Deich:** You've suggested that these approaches are complementary, and in an ideal world this is true, but you have to think how Congress works. If you have two approaches side-by-side, Congress will pick the more favorable one and ignore the cost-benefit analysis.

**Nadiri:** I disagree. You'd have to do cost-benefit analysis anyway. The production function shows the level you need to spend and says nothing about choosing between projects. You would still need cost-benefit analysis to make project selections.

**Rubin:** What can one say about ambient environmental effects of infrastructure?

**Munnell:** I was struck by the notion that these effects cannot be captured in cost-benefit analysis. Why not?

**McGartland:** They are, in fact, included in EPA analysis.

**Aschauer:** But wouldn't these things be subject to even greater sensitivity to the assumptions than the production function approach or other approaches? I would say that cost-benefit analysts are presumptuous when they say that, even when an analysis is done well, they can conceptualize and capture all the economic and social relationships properly and completely.

**Jacoby:** Externalities are tough. But how about the value of public capital itself? The quality of capital is not captured at all.

**Nadiri:** The usual way to capture this is to use a proper definition that in principle captures vintage and other effects that affect quality. But unfortunately, our deflators generally have no other force than convention. A majority of people use nothing other than GNP.

**Jacoby:** What about roads - depreciation and the value of the components of roads? What is the economic life of these components - rights-of-way, subgrade, and pavement - and how do we account for these differences?

**Nadiri:** One of the benefits of an exchange of this type is to refine and exchange knowledge and this will provide economists with grist for their mill in developing appropriate depreciation and other measures.

**Munnell:** Let me add that it's even worse for state data. There are no state data and the range of errors is large.

**Aschauer:** To put this in perspective, the depreciation problem is more severe in the case of R&D capital than in infrastructure capital. What is the relevant service-life for new knowledge? Analysts probably have put too much trust in the estimated elasticity for R&D capital.

#### **1:15PM - 4PM: Afternoon Discussion Sessions**

The afternoon session began with a presentation by Cameron Gordon, Study Manager for this study for the U.S. Army Corps of Engineers, Institute for Water Resources.

#### *V. Presentation of Strawman by Cameron Gordon, U.S. Army Corps of Engineers*



**Gordon:** Let me explain where this strawman scope of work originated and how we hope you will use it. The scope of work was originally developed as a project to be undertaken by the Corps of Engineers, Institute for Water Resources as an element of the Federal Infrastructure Strategy study. However, we soon realized that the project scope was too broad for the Corps alone and, moreover, that we needed to find out what our audience - namely Federal agencies and policymakers generally - wanted to achieve. Hence, we are holding these workshops to get the agencies involved in designing a research plan.

Note that this strawman isn't a request for a proposal; it is a focus of discussion to make use of the group we have assembled here in building a new plan which bridges the gap between the academic and policy debates. In focusing, we ask you not to get bogged down in technical details at this point; it's too early in the process. Rather, consider the following:

1. Scope of Exercise: What modes should be examined? What is the appropriate time horizon? Is the focus on planned Federal expenditures appropriate? Are these the relevant economic variables?
2. Data: What data are necessary and appropriate for the study?
3. Models: What approaches are most useful (we'll get to specific examples of functional forms later on).
4. Standards: How do we define standards of proof and evidence? What standards would satisfy most critics?
5. Objectives: What questions are we trying to answer? What specific products do we want from this effort?

There are three workshops planned: this first one and two to be held in the months following. In these later workshops, we must also discuss issues of participation, e.g. administration and oversight of the effort.

**Munnell:** Can we just focus our efforts on perfecting cost benefit analysis?

**Schilling:** Yes, if we all end up agreeing that is, in fact, the best way to proceed.

**Antle:** Efficiency of infrastructure investment is key with today's tight budgets. The question that should be asked is should money be spent on expansion, maintenance, or shrinkage?

**Schilling:** The National Council on Public Works' recommendations are to be used as a guide for this project. We strive for Federal participation in this effort. If the group would examine

Dr. Stearns' eight original questions, maybe we can identify approaches to answer those questions. Benefit-cost analysis might answer many of them.

**Jacoby:** Not true; benefit-cost analysis only answers a limited number of those questions.

**Munnell:** The production function answers only the first one.

**Hady:** I have no problem with the scope *per se*, but are we studying enough in terms of the modes suggested? Are we excluding some important aspects? Should the term infrastructure be expanded to include areas such as education?

**McGartland:** The assumption of the proposal is top-down, i.e. determine the optimal level of investment and then allocate it. But these are all independent decisions. Why not look at them independently? Perhaps the study should be decentralized. That is, do a bottom-up approach where one is comparing the net merits of increased spending by area.

**Nadiri:** I hear a number of things. First, the Federal agencies are doing a lot and analyzing it in many different ways. So you get an inventory of methods and results as a start.

But by itself this is not enough. How do you link the pieces of the infrastructure network together? What are the linkage effects? The nature of infrastructure and its institutions have changed; how do we assess these impacts?

So we have to answer these questions as well. But having answered all of these questions, we still could do productivity analysis for it will tell us what all of these investments will do to the national economy.

**Jacoby:** Stearns' questions are general, while the scope is project specific. We should do a more general, empirical approach. What we should not do is answer questions like appropriate locations for projects.

**Williams:** One issue here is that politicians tell us what they want and we do it. So one starting point is to ask what the year 2000 or 2010 could be like or should be like. Also there are plenty of programs likely to happen or definitely going to happen and we should proceed by including them in our analysis. Again, do a bottoms-up approach: identify the areas of need and then investigate the optimal spending level of these areas.

**Clark:** I think Stearns offered questions which were designed to enhance the strawman, not supplant it. The original intent of the strawman was to help the group establish a focus and develop an agenda that was their product.

**Hady:** I agree. I don't think we've kicked around this strawman at all and it deserves a few good kicks.





**Rubin:** I think what we're trying to get at is finding tools which we can use to analyze our decisions; at least that was the original aim of the project as I heard it early on. Now we're getting into the application of those tools - the uses to which they would be put - and that's unfortunate.

**Lyon:** I think there's a disconnect here between the opening remarks and the scope. Stearns' questions are good, basic ones, but the scope of work seems to address different and perhaps not especially relevant questions. We have to know what the size of this effort will be, who will be doing the work. The framework of the analysis must be laid out.

**Williams:** Our problems are different than they used to be. In the old days, roads used to have the benefit of moving people. Now we're destroying the country by moving people and we have to think about what to do differently.

**Eberts:** I think what we seem to be shooting for is one particular client and one decision rule they're seeking. But in fact we have many clients and many decision rules. ISTEA (The Intermodal Surface Transportation Efficiency Act) went from an efficiency project to a jobs project. So we need information and approaches for each one of these things.

**Rubin:** Tools are where the link is made between the strawman and the questions Stearns asked. You don't stop at tools, but it is where you begin. For example, does the scope of work examine the right economic indicators?

**Jacoby:** I do not think we should emphasize the evaluation of particular projects. I don't think we should focus on cost-benefit analysis. We should be looking at emphasis, changing patterns, the way we should be responding to structural changes such as the changing relationships between firms in production, sectoral shifts and so forth. Where do you put your money for the biggest bang?

**Lyon:** Your comments are really interesting. My personal position is that the place where the Corps could make the best contribution would be to look at projects, select a randomly stratified sample of those projects, and then go back and see if those projects panned out. Did you catch all of the benefits? Can you go back and find secondary effects that were not computed? Was the analysis wrong in the beginning? That's the comparative advantage of Federal agencies; have all your agencies do this and compare. The comparative advantage is not with agencies to do macro-economic, aggregate analysis - that's for academic shops and cottage industries.

**Munnell:** It would be great if you knew whether investments should go towards Medicare or infrastructure and then within that MAGLEV or fiber optics, but the econometrics is so loose on this that we can't really say much.

I don't know much about cost-benefit analysis, but it would seem better to review the practices of agencies and compare. There is so much loose talk that we need to get the terms straight.

**Jacoby:** The Transportation Research Board has a primer on transportation cost-benefit analysis.

**Eberts:** The World Bank has also gone back to check on the performance of some of its cost-benefit analyses.

**Antle:** Historical examination of projects have been done and they tend to verify that the benefits ultimately are often much different than what type of benefits were predicted. This is not to say that the projects weren't beneficial, just that the effects ultimately realized were different from those predicted. For this reason such historical case studies are not especially useful in looking forward and making decisions about the future.

**Jacoby:** I would like to know what sort of data the number crunchers need to run the models.

**Eberts:** I reemphasize that point. We can't get data from the agencies. We have to find it ourselves and make imputations. Also all the agencies have their own data. The problem is in the data, not the models.

**Williams:** A reasonable answer to the charge that we don't know what infrastructure does is to say that we don't have the information we need and require more support in getting that information.

**Blechman:** What about the comparability issue?

**Hady:** Each model needs different data, so it will be difficult to compare them.

**Bell:** The different approaches yield different results, each of which is useful depending on the purpose you have. So they're not competing, but complementary. You cannot do cost-benefit analysis without knowing what the links are between industries.

**Nadiri:** I was impressed with the fact that people put forward the elements of what you need to answer the question. We must realize that the data do not exist in a currently usable form. Also, the approaches discussed today are complementary, so one should not ask the same questions of each approach.

We shouldn't be short-circuited by the questions proposed. What the organizers should do is go back and fine-tune the questions and assess which methods best answer different questions.



**Lyon:** But we need to know where to look. Cost-benefit analysis tells you this. Otherwise, it's a leap of faith. In addition, cost-benefit analysis does catch spillover effects.

**Nadiri:** Don't think that cost-benefit analysis tells you that for it's a macro question on some level. We need to know what the links are.



## HIGHLIGHTS OF THE SEPTEMBER 17, 1992 WORKSHOP TO DESIGN A SCOPE OF WORK TO STUDY THE ECONOMIC IMPACTS OF FEDERAL PUBLIC WORKS INVESTMENTS

### **9:15AM - 9:45AM: Welcome and Introductory Remarks by Dr. Robert Stearns, Deputy Assistant Secretary of the Army (Civil Works) for Project Management**

Dr. Robert Stearns welcomed the participants who then introduced themselves. His introduction was followed by a panel consisting of Ann Grambsch and Al McGartland with the Environmental Protection Agency; Robert Wescott and Kurt Karl from The WEFA Group, Inc., a macro-econometric modelling firm; and, Adam Rose, an expert on input-output (I/O) analysis from the Pennsylvania State University.

**Stearns:** I would like to add to my remarks made at the opening of the first session. Two concerns came to mind which led to the original list of eight questions: 1) We didn't want this study to appear to be a self serving study (that is, we didn't want agency personnel deciding that we need more infrastructure); and, 2) we couldn't get them from here -- there obviously is not enough time/resources to answer all the original eight questions - the questions were too esoteric. Today's focus is the value of infrastructure investments on the U.S. economy; what can we do in two years to answer this question, and how do we do it.

Keep in mind what we are here for today. This study is only one of a number of projects the Corps has under way as part of its overall Federal infrastructure strategy program. This study doesn't need to answer all the questions. Let's focus on the questions raised in the strawman and come up with approaches to answer some of the original questions. Some possible avenues to explore include the data needs to be used, the development of a common language between the agencies, and the optimal level of investment. In summary, let's make progress today by deciding which approaches should be taken.

**Blechman:** The session should probably facilitate itself. Remember to focus on the big question: What research can be done in two years to evaluate the impact, particularly the economic impact, of public infrastructure spending.

This session will be less free-ranging than the first workshop. Our goal today is to move to specifics: what are the research projects, how would they be constructed, what are their goals.

The last workshop consisted largely of personal views. Today, we would like to do the same unless the participants, for the record, indicate that they are speaking for their agency. Next workshop, we will ask that all remarks be agency-based.



## 9:30AM - 10:30AM: Panel Presentations

### *I. Presentation of Al McGartland and Ann Grambsch, Office of Policy Planning and Evaluation, U.S. Environmental Protection Agency*

**McGartland:** Ann Grambsch will be doing a presentation on EPA's Section 812 study regarding the benefits and costs of the Clean Air Act in the United States. EPA, with an annual budget of almost \$7 billion, is largely a regulatory agency. EPA's official position endorses the use of cost-benefit analysis, although there are various exceptions throughout the agency.

**Grambsch:** In many ways our Section 812 study has an intent similar to that of the Corps' study: we wish to look at the macro picture, but to accomplish this task, a micro-level analysis is needed. What we at EPA are doing, is to examine the situation with and without the Clean Air Act and then comparing the results. There are two main components to this analysis: an assessment of costs and economic impacts and a benefits assessment.

The most difficult issue we have had to grapple with in our with/without comparison has been specifying a baseline. We have had to make a number of simplifying assumptions. For example, in answering the question of what states would have done in the absence of the Clean Air Act (CAA), we have assumed that all costs and benefits accrue to passage of the Act. We also assume no change in firm location patterns.

The assessment of costs consists of examining changes in pollution abatement expenditures over time and changes in defensive and mitigating expenditures over time which together lead to an estimate of net changes in economic activity over time with and without the CAA. We have a big problem here in specifying the components of these changes. Conceptually, we'd like to get to this.

It is not sufficient to look just at engineering cost-accounting. We also have to look at general equilibrium and macro-economic effects, and the economic dynamics these entail. We have selected the Jorgenson-Wilcoxon (JW) model to do this. The JW model is general equilibrium and dynamic and focuses on the intermediate and long-runs. **The model does not examine the short-run effects.** JW is a full-employment model, a micro-economic general equilibrium model. Cost and other functions are econometrically estimated so some behavioral response is captured.

The assessment of benefits starts with the net changes in emissions due to the CAA. From this estimate, an estimate of net air quality changes is made using various existing models of physical processes (e.g. acid deposition). From this estimate, we can compute net changes in health and welfare (using medical studies and other literature), then estimate net changes in economic damages. This last step is complicated and consists of coming up with a dollar value

per incident or episode of damage, conducting additional modelling of effects on, say, agriculture and prices, and so on.

One has to aggregate these things meaningfully. Another significant issue is dealing with uncertainty.

**Robinson:** How do you value human health benefits?

**Grambsch:** We use contingent valuation and panel discussions. Much work has been done on this issue which we can draw upon.

**Nadiri:** I have three questions:

1. How do you establish the initial or baseline conditions?
2. How do you account for the issue of not considering aggregate demand at all (because the long-run model might introduce bias), given demand certainly exists?
3. If the study is looking forward, how do you account for the change in business conditions and patterns?

**Grambsch:** Regarding the last question, we expect locational changes to occur. Our simplifying assumption is that everything will stay as it is. Without firm evidence anything else we would assume would be arbitrary. In establishing the baseline conditions, we have the "cost-of-clean" estimates. We have a history, in other words. Then we take those costs out and run the simulations. On the demand side, we can't look at unemployment since that is a short-run effect and this is a long-run model, but given the long-run focus this may be an acceptable simplification.

**McGartland:** I would like to add that in addition to the Section 812 study, EPA is also doing cost-benefit analyses of the Superfund and clean water programs.

## *II. Presentation of Robert Wescott and Kurt Karl, Wharton Econometric Forecasting Associates, Inc. (WEFA)*

**Wescott:** We at WEFA feel that today's topic will be a key policy issue of the future. The WEFA model is a 1,000 equation Keynesian model, which also has a supply-side driving output and a financial equation block to model flow of funds.

There are two effects of public infrastructure: **normal effects**, which consist of multiplier effects, i.e. the direct and indirect effects of the first spending round; there are also input and



output effects and productivity gains, some of which are "normal"; there are also **special effects**, cost changes which are the dual of the productivity question and the transmission of these productivity effects. Our model also looks at sectoral effects and international effects.

At this time, I would like to turn over the presentation to my colleague, Kurt Karl, who will describe the model in greater detail.

**Karl:** The WEFA model contains exogenous inputs for demographic changes and population growth. There are a couple of markets in the model, i.e., the goods and the labor markets. When there are imbalances between these markets, prices adjust and thus affect GDP. There is also a financial market.

Now consider an infrastructure investment. This investment will lead to financial changes which will affect demand, which will affect prices, which will affect output. Sectoral effects will simply replicate the overall demand model for as many sectors as exist. The model is recursive in that an I/O model, driven by the macro model, creates sectoral effects which then feed back into the macro model which feeds back to the I/O model until a satisfactory equilibrium is reached.

A further level of sophistication is represented in our model by having the price vector affecting the structure of the economy. Thus, given production functions for all of the sectors, we can have prices feed back into the I/O model and change the structure.

**Aschauer:** How are the macro-economic and the I/O models kept consistent? That is, if the macro model effects change costs (I/O coefficients), how do you handle it?

**Karl:** We would have to do an external evaluation of the changes in cost structure involved, possibly using an outside accounting firm to estimate such changes.

**Grambsch:** Does your model distinguish between government-provided capital stock as opposed to privately-provided capital?

**Karl:** No. Our model only contains private capital, not government capital.

**Deich:** How does the macro model distinguish between Federal infrastructure spending and other forms of government outlays?

**Karl:** The only distinction in the macro model is between factor compensation and purchase of goods. Thus, there is no distinction between infrastructure spending and paper clips. However, we are aware of this limitation and are currently focusing our efforts on compensating for it.

### *III. Presentation of Adam Rose, Pennsylvania State University*

**Rose:** My talk will differ from the first two presentations, in that it will be a more general talk on the input-output model and its potential applicability to the estimation of the economic impact of Federal infrastructure spending. I would like to start by contrasting the I/O approach (in its most basic and limited form) to where I/O has gone in the last fifty years.

There are two types of I/O analysis: a basic version which is a static, linear model of all purchases and sales between sectors of the economy, based on the technological relations of production; and an ultimate version which is a dynamic, non-linear model of market and non-market interactions between sectors and institutions of economies, based on production technology and any other variables that can be quantified. The essence of I/O generally is to model all economic interactions between sectors and/or institutions with an emphasis on production requirements.

There are numerous advantages of an I/O approach; it is an organizational framework for data; it is comprehensive and detailed; specific models are readily available; it has computational ease; it displays economic structure and reveals economic linkages, it can be used to calculate total (direct, indirect, and induced) impacts; it is readily extended (to consider institutions, and pollution, for example); and it is compatible with other models and engineering data. There are also disadvantages: prices play a secondary role, linearities are difficult to overcome, and I/O lacks a forecasting ability.

Comparing I/O and other models, I/O can readily be converted to an optimization model (e.g. a Linear Programming format); it can serve as the database for intermediate inputs and some overall accounts in CGE models; it can be extended to forecasting (e.g., INFORUM); and can be conjoined with macroeconomic models (e.g., REMI).

As for the applicability of I/O to infrastructure impacts, construction impacts are a very straightforward application of I/O; one uses itemized (sectoral) construction costs as a change in final demand, and modelling of backward linkages. There are limited insights for broader impacts from the basic version, since it includes direct and indirect market impacts of only some types of infrastructure (e.g., hydroelectric generation); omits direct impacts of non-market infrastructure (e.g., non-toll roads, bridges); and omits non-market indirect impacts (external economies brought about by productivity improvements and external diseconomies due to pollution).

The applicability of I/O to impacts of infrastructure operation are more limited given the current state of modelling and data collection. However, a number of refinements are possible, including the specification of nonmarket infrastructure as I/O sectors, adjustment of other I/O coefficients to reflect productivity improvements, and so on.





Also refinements are being made to give I/O greater capacities for regional and socio-economic disaggregation:

1. Most infrastructural impacts are relatively more intense at the regional level. There are some regional counter-cyclical or economic development objectives for public works expenditures. There are a number of good non-survey tables or multipliers available and many I/O databases are also available to estimate location tendencies and competitive advantage.
2. Most impact analyses are done in terms of aggregate economic indicators (even cost-benefit analysis). The distribution of impacts are important as well; for normative reasons -- equity or fairness, and positive reasons -- public choice/support. Other distributional categories include racial/ethnic and occupational impacts; I/O models (and SAAM) have been extended to analyze these concerns.

A research agenda for this project could include development of infrastructure capital and current account coefficients and infrastructure externality coefficients and coefficient adjustments. Other possibilities would be to explore the uses of I/O databases, improve databases at the regional level and explore the use of I/O in conjunction with other models; and perform tests of accuracy of I/O model predictions.

#### *IV. Morning Discussion and Panel Questions and Answers*

**McGartland:** I have a concern. I believe we are taking a step back from the first workshop, where we spoke of productivity measures of infrastructure investments. We should not use infrastructure investment as counter-cyclical policy. None of these models capture noneconomic benefits (i.e., clean water, clean air). Productivity is important, but it too is exogenous in these models. Basically, we want to find out, at the margin, how and if these investments improve society.

**Bell:** I agree with McGartland's comment. The multiplier effects of infrastructure investment are important, but not the only issue. For example, how do you pick up distributional impacts? And while you may be able to quantify impacts, how do you determine whether they are costs or benefits?

**Grambsch:** I think the deeper issue is that much of the current research focuses on the production/costs side of productivity changes because they can be measured well. What we cannot measure well are the benefits side. We should focus on this.

**Bell:** It is difficult, at times, to distinguish costs versus benefits. The catalytic convertor is an example. Is any technological change interpreted as a cost?

**Grambsch:** These tools have been developed and we are able to crank through some of this. For example, JW uses 600 representative consumers.

**McGartland:** Since we have limited resources, I would like to focus on what we are buying. We should not put money into macro models, but into developing and quantifying what those models take as exogenous.

**Moomaw:** We need to use existing infrastructure more efficiently; O&M and congestion pricing are examples.

**Wescott:** There are two questions here: 1) How should we rank projects? and 2) What is the optimal level of investment? The macro model can get to the optimal level. Macro models are useful in contemplating how an economy should organize itself; that question contributes to the policy debate.

**Deich:** Even using a macro model, you need to rely on other models as support, such as the production function. Your models take as exogenous types of capital and its effects for example.

**Aschauer:** The same can be said of the JW model and benefit cost analysis.

**Bell:** All of the approaches have some contribution to make, depending of what question you're asking. If there is a relationship, can we quantify it? If we can do this, how do we allocate resources? The macro model tells us how much, but not how to spend.

**Nadiri:** We need to focus on a number of issues. What are the special characteristics of public infrastructure? Why is infrastructure publicly provided and not privately supplied? What ever model you use, these issues must be addressed. In deciding over different types of public infrastructure, policy makers want to see alternatives: what are the priorities -- clean air? Also technologies change and adapt over time. Finally, one model will not answer all questions, so we need to think of series of complementary activities.

I have one question on the I/O model; how do you model externalities?

**Rose:** Some externalities are difficult to model, such as producer-to-producer externalities. Producer-to-consumer externalities are easier; pollution coefficients have been calculated and used with the I/O model.

**Stearns:** Let me ask a rhetorical question. How will we pay for infrastructure investments? I have two answers: 1) get the money elsewhere by cutting something else (then counter-cyclical effects are zero) or 2) charge user fees. Can these models distinguish between various taxing/financing methods? Actually, there is a third method; simply mandate or regulate the private sector to provide the infrastructure.



**Blechman:** Let me interrupt as we are getting close to lunch. Cameron Gordon will do a short presentation a list of four major questions that we would like discussion on this afternoon.

**Gordon:** There are four issues that this workshop should focus on: 1) should this study compare models, use different models for different tasks, or both? 2) what approaches should be used for which tasks? 3) how long is the long-run for study purposes? and, 4) which impacts are feasible and useful to study (see list on Page A-3). I might mention that the data questions are not included here. I realize that this is a crucial question, but let's keep it in the back of our minds for now. In addition, the panel discussion we heard today was, in effect, a strawman panel. We want to use the presentation of these models as catalysts for the afternoon discussion.

Keep in mind also that the strawman scope of work limits this study to Federal infrastructure programs and the sector categories in Fragile Foundations.

#### **1:00PM - 4:45PM Afternoon Discussion Sessions**

**Blechman:** Let's review the areas that need to be discussed this afternoon: 1) allocation of resources among categories; 2) optimal level of expenditures; 3) public (state and Federal) versus private provision; 4) optimal financing; and 5) project specific assessment.

**Lyon:** I think allocation of resources among categories, optimal level of expenditures, and project specific assessment can be grouped together. If it is possible to determine the rate of return, then those three questions could be answered. Allocation of the rate of return is key.

**Nadiri:** I agree that these are all allocation and rate of return questions.

**Lyon:** Also, we can group the remaining two tasks together into the means of delivery or means of financing.

**Pietrowsky:** The means of financing may be outside of this project's scope. The Corps of Engineers has other studies under way which examine these questions. This particular aspect should be assumed for this project.

**Blechman:** Let's start with how long is long-term; the year 2000? That is, as Cameron said, pretty close.

**Lyon:** I think you have to look at the return over the investment's lifespan. That is definitely not short term.

**Jacoby:** Some capital investments have an extremely long life. The time-span should therefore be long.

**Gordon:** Does this exclude the short-run?

**Nadiri:** It is not mutually exclusive. After the decision is made (after calculating rate of return) to invest in infrastructure, the first impact would be on the demand side. The ultimate effect of increased demand would be to increase the requirements in the capacity of the economy to produce and the corresponding requirements for inputs. The lag structures and the dynamics between supply and demand mean that the short-run and long-run are not mutually exclusive.

**Emerson:** The effects during the investment period are relevant. For example, during a recession, the real resource costs are less.

**Lyon:** Is there a Keynesian impact? At OMB, we assume there is not.

**Nadiri:** You make a decision on programs and projects based on the long-term rate of return. But once the investment is in place, these big projects have important short-term effects in terms of allocation.

**Blechman:** Our second issue for this afternoon is of how we narrow the scope; what do we mean by infrastructure?

**Jacoby:** We should not just look at central government expenditures. We need to look at all levels of government.

**Bell:** Use the Fragile Foundation categories plus energy and telecommunications. The Fragile Foundations categories were limited to those which support economic activity, not ownership. Ownership is not such a big issue.

**Emerson:** Telecommunications should be included because it is a direct competitor to transportation.

**Blechman:** We seem to be saying the study should include all levels of government and physical infrastructure, including energy and communications? Is this scope too big? What about privately held support facilities?

**Jacoby:** Maybe to limit the focus to public infrastructure is wrong. Private facilities must be included, but the line must be drawn somewhere.

**Rose:** How about distinguishing between public goods and private goods? Public goods can be shared irrespective of who pays for it. Thus, our criteria perhaps should be the same as those used to distinguish public from private goods, i.e. nonrivalness in consumption and excludability.



**Nadiri:** I believe the scope is too broad and ambitious given the budget and timing; let's narrow it to be more successful. The scope could be limited to 2 to 3 major public capital categories, Federal or not, which have a major impact on the long-run capacity of the economy. We could then examine where those impacts occur and build in cost-benefit analysis and other approaches.

**Blechman:** How many categories should be examined? Is 1 or 2 too small? How about all of the Fragile Foundations categories; is this too many?

**Bell:** The number of categories is determined by whatever "theme" the categories are judged by; find a general theme which is important to the development of the economy.

**Nadiri:** That is correct; ask what 3 or 4 (or whatever) categories will facilitate the development of economy, or certain strategic sectors of the economy. Then calculate the rates of return for those categories which will produce a ranking and an estimate of macro effects.

**Bell:** Accessibility or environmental concerns may be the theme; it depends on your overall priorities.

**Nadiri:** Ask what are the potential services that the economy would need that the public sector can provide.

**Blechman:** In consideration of the time remaining today, it doesn't appear that we are going to be able to choose the categories; so let's focus on the process.

**Gordon:** Let's list the Fragile Foundations categories. Water: resources, supply, and wastewater. Transportation: highways, air, and mass transit. Waste management: hazardous and solid. Today's additions are communications, education, public buildings and property, and energy.

**Nadiri:** Let's concentrate on those categories which will enhance the productivity of the economy in the intermediate run. Productivity is the key problem that this country faces.

**Schilling:** I hear some talk about including education, but I think education is outside our budget and scope.

**Bell:** I agree that education is outside this group's expertise. If the categories are guided by their contribution to enhancing the Nation's overall accessibility, this means focusing on transportation and telecommunications.

**Jacoby:** Should we limit it to physical infrastructure?

**Blechman:** Federally-leveraged expenditures, shared public goods, and physical infrastructure is what I am hearing everyone suggesting the study should focus on.

**Nadiri:** Let's not worry now about the ownership aspect at this point.

**Blechman:** Can we name the criteria for including infrastructure in the study? I hear it being suggested that the study should focus on infrastructure if it is an input good, public good, a critical factor in interstate commerce, or in enhancing the productivity of the economy. Many participants seem to like the idea of having both publicly provided facilities (such as transportation) and privately provided facilities (such as telecommunications). However, given the time, I think we agree that these decisions are to be delegated to the Corps to decide and then presented at the third workshop.

**Nadiri:** Within the outlined criteria, accessibility and sustainability are the two key themes.

**Stearns:** I have a couple of observations: 1) it doesn't appear that this study can address all the Fragile Foundations categories. Thus, they must be cut down or modified; and, 2) since the Institute for Water Resources is the sponsoring agency, water resources must be included as a category. We don't want to give the impression that the Corps is into analyzing other agencies infrastructure responsibilities, but not its own.

**Blechman:** The next issue is what impacts are useful and feasible to study. Participants have suggested a number of additions to the list of impacts we have thus far, including regional, distributional, and environmental impacts. Let's take a straw poll on ranking the top five impacts, based on feasibility and priorities.

This poll had the following results (with participants allowed to vote up to three times):

Factor Impacts: 12	Output Mix by Sector: 9
Output Mix By Region: 6	Employment: 9
Monetary Variables: 8	Trade Balances: 5
Industrial Organization: 4	Public Sector Tax and Fee Revenue: 2
Distributional Impacts: 8	Environmental: 7

**Blechman:** The next issue that we are to discuss is which models/approaches should be used.

**Bell:** The technique you use depends on the what the questions are. The approaches are complementary and should be used together.

**Wescott:** Exactly. For example, our macro model would be used with an I/O approach.

**Rose:** We should talk about models which can measure the rate of return on capital.



**Nadiri:** Impacts and rate of return are part of the same analysis or methodology. The way it works is that you have a model and a number of inputs to the model, then you run the model and it calculates the rate of return for each type of capital.

**Jacoby:** The only methodology that we have discussed which will produce a rate of return on capital is cost/benefit analysis.

**Nadiri:** As discussed at the last workshop, the production cost function will calculate the rate of return and some of the effects discussed earlier. If you are measuring the aggregate, industrial dispersion of the effects then you need to use a combination of models.

**Clark:** What rate of return should be used: public, private, or social?

**Nadiri:** The social rate of return could be used.

**Gordon:** What I am hearing is that a direct comparative exercise is not worth doing; is this correct?

**Lyon:** No. This whole project is a result of David Aschauer's work and results. How do we measure the validity of the cost-benefit analyses that are used? David Aschauer calculates rates of return of 40 percent for transportation and cost-benefit is calculating 10 percent. More work needs to be done in this area as some spillover effects are apparently being lost.

**Blechman:** (After asking for a show of hands) Well over half of the group thinks that a direct comparative exercise is worth doing.

**Nadiri:** This comes back to the same issue, namely that the model to be chosen is dependent on which questions you are most interested in.

**Deich:** Macro-economic modelling approaches should be down on the list. We must validate or invalidate the production function's earlier results.

**Lyon:** Cost-benefit analysis can be done at the programmatic level; look at EPA's analysis of the Clean Air Act. A comparative approach should be taken; cost-benefit may not calculate all effects - it may be dropping some externalities; if so, the econometric (production cost) models can be used to tell us where to look. Let's do more work on micro level results, studying at a programmatic level.

**Aschauer:** I think that we can make use of the production cost function approach to try to capture some inter-industry spillover effects of various infrastructure investments.

**Blechman:** We can narrow the differences between cost-benefit analysis and production function analysis and make them work together to get the answer.

**Rose:** I would sum up the approach a little differently. To enhance existing studies and techniques, we could do the following:

- Use cost-functions to analyze individual industry impacts
  - broadened by macro, CGE analysis;

- Use aggregate cost/production functions to estimate aggregate impacts
  - disaggregated through CGE, I/O analysis;

- Use cost-benefit/partial equilibrium analysis for programmatic analysis
  - enhanced by general equilibrium though CGE

#### *IV. Conclusion and Adjournment*

After some further discussion and a straw poll, the facilitator summed up:

**Blechman:** We seem to have identified three research needs and goals: 1) the need to extend the reach of micro analysis to include more network and external effects and compare to the aggregate approach (production cost function); 2) the need for work to be done at the programmatic, inter-agency level (for the cost-benefit side); and, 3) the need to examine multi-sector linkages.





## HIGHLIGHTS OF THE NOVEMBER 6, 1992 WORKSHOP TO DESIGN A SCOPE OF WORK TO STUDY THE ECONOMIC IMPACTS OF FEDERAL PUBLIC WORKS INVESTMENTS

Kyle Schilling, Director of Institute for Water Resources, welcomed 24 participants from Federal agencies and academic institutions. Unlike the previous two workshops, this meeting was not addressed by a panel and was set up as a working session to finalize the scope of work.

**Schilling:** Good morning and welcome. Today, we will focus on getting agreement on the details of the strawman, set up an administrative structure that allows us to proceed, and explore the possibility of producing a meaningful document early in the research agenda. Finally, we would also like to gauge agency participation: funding, data, expertise, time, etc., and consider the timing of release of research products.

**Blechman:** We have some basic questions that we have to answer today. What's the plan? Who is going to do the work and when will it be done? Is your agency participating? I realize that some of you may not yet be in a position to answer these questions, but some of you are and we need to hear from you. Now let me turn it over to Cameron.

(Cameron Gordon, Study Manager, then reviewed proposals for additions and deletions to the strawman that he had received thus far; he stressed the need to pare down the scope, saying that while things may be added, the overall research plan should be cut. Then Gordon raised the issue of the time-frame for the effort and the products to be delivered.)

**Rubin:** I see two sets of products: 1) Here is what we will be doing; and 2) the results of what we end up doing.

**Schilling:** Can we get something out in March?

**Aschauer:** It's my perspective that we should get out knowledge about the effort early that shows that we're doing something relevant.

**Grambsch:** Analytic tasks take time and you can't rush them. Data collection alone, on the other hand, can be reported on earlier. We could also produce a literature review and research plan as well.

**Blechman:** Does the silence indicate that economic analysis is apolitical?

**Jacoby:** Yes, in the private sector, there's a bottom line. In the public sector, the existing methodologies are wanting because there is no comparable and easily identifiable bottom line. We want to compare methods and see if they can be used together to get at the issues. In this

sense, we're doing pure research. What we are doing, in relation to the new administration, should not change. Our purpose is to bring the two methods together, to illuminate where they support one another, where they differ, why they differ, then use these two methods as a tool, a package. When we crunch the numbers, then the political devils will come out.

**Starler:** Can we say anything now about infrastructure investment effects, for example, signs and magnitudes? Can we say anything in an interim report about general policy initiatives?

**Jacoby:** Yes, but only generally and roughly. Signs we have some idea about, magnitudes we don't. Everything can fall under the rubric of infrastructure and we can't really distinguish between modal effects.

**Schilling:** A data report, including information on how it was used in past research, could be useful early on.

**Grambsch:** One of the dangers is that the results of different analyses are not comparable because the methodologies are different; rank ordering is misleading. That's why we're undertaking this effort, at least in part.

**Starler:** Let me be the devil's advocate. Would you want to say "Hey, administration - we don't know enough about infrastructure? do something about health care instead?"

**Grambsch:** You want to say what you're able to say, no more.

**Aschauer:** Let me give you an example from a macro perspective. There is some evidence that the deficit doesn't have real impacts. On that alone you don't say: "Don't do anything about the deficit". The infrastructure issue is comparable.

**Williams:** We can't stop people from misusing this study, but we can say that researchers need to know this. The message we need to send is that more research is needed before reaching firm conclusions.

**Rubin:** It would not serve this research agenda to rank order anything as far as this project or that one. Let's stick to the data and say what we can say in the interim.

**Aschauer:** What about putting out B/C estimates that show some projects should go forward? Would that be upsetting to you?

**Rubin:** I think that we can say that B/C is a useful screening tool.

**Gelston:** You can't add those B/C analyses up.



**Rubin:** No, B/C can't tell you the optimal level of investment.

**Jacoby:** Is there any evidence that B/C overstates benefits?

**Lyon:** Yes, B/C analysis shows benefits that other methods don't.

**Aschauer:** Yes, if B/C analysis is done well. But can it be done well?

**Lyon:** Is it done at all in most instances? B/C analysis does not under-estimate productivity. Federal agencies only recently have started using B/C analysis to evaluate programs, mostly in retrospective analyses.

**Schilling:** The question of whether B/C analysis is done well or often enough is different from the question of whether it is sufficient.

**Gelston:** We did this years ago. The Bureau of Economic Analysis used to have a model for net national benefits and regional effects could be often be double-counted under this methodology. Yes, B/C analysis can overstate benefits.

**Aschauer:** But I thought the question was whether we could do something reasonable over the next three months with B/C analysis? Do we have confidence in existing B/C analysis?

**Grambsch:** Yes, there are expenditure numbers to work with, but calculations of benefits and costs are often not comparable. GAO differs from CBO for example. Which B/C analysis should be used?

**Aschauer:** I agree that's a research question, but we don't say that we don't know anything.

**Grambsch:** Yes, but if you get those numbers into the public domain, even if caveated, they can be misused too easily.

**Aschauer:** True; all you need is one table.

**Gelston:** You need to know not only where the biggest bang for the buck is, but how much.

**Hady:** The new administration also wants to know the timing of that bang.

**Jacoby:** We want to stress that the issue we're ultimately addressing is the relationship between infrastructure and productivity.



**Rubin:** I have no disagreement with that, but in the description of our research, we want also to stress the importance of the Fragile Foundations work - the body of work it represents and its shortcomings. That's a good foundation for the new administration to work with.

**Schilling:** Good point. That other work was done outside the Federal framework. This work is bottoms-up and from within.

**Blechman:** Let me test this - should we focus on productivity?

**Munnell:** My concern in the scope of work is that if you focus on this alone, you lose alot. I note that the increase in leisure time, mobility, etc. are not in the scope of work.

**Blechman:** That's a content issue, not an interim report issue; do we agree?

**Grambsch:** No, we should list all the potential benefits. Building wetlands has no productivity impact, but important social and environmental impacts.

**Bell:** This is an outline of an interim report; a review of past work, progress made, identification of research needs, why this project is important and how it represents progress in the debate. Before Fragile Foundations, the only effects of infrastructure which were focused on were counter-cyclical effects. Fragile Foundations noted the intrinsic value of infrastructure. Now we're asking where we should spend our infrastructure dollars.

**Kort:** Don't emphasize productivity. We don't measure it well enough. Put it near the bottom of the list.

**Jacoby:** There are two considerations at the top of the national agenda: 1) the environment and, as a sign I once saw said, 2) 'the economy, stupid'. I am better off with transport amenities - I don't want to sell that short. But I want to emphasize productivity because that issue is so important right now. You don't want to muddy that message. The central message of the times is the economy.

**Lyon:** But a dollar is a dollar, where ever it's spent.

**Jacoby:** I don't disagree with that; I merely suggest a particular emphasis.

**Blechman:** I see two sentiments being expressed: 1) There is no disagreement on productivity - it should be examined, but as only one of many factors; and 2) The study should be based on Fragile Foundations.

**Williams:** I disagree, Fragile Foundations was hard on transit, which was the tone of the times. There was a lot of uncertainty surrounding the measurement of transit impacts and it hasn't been



resolved yet. I'd like to make a pitch to discard modes altogether in the transportation arena. Put the modes together along service lines. I've been in this business for 14 years and I'm tired of statisticians driving the policy decisions - i.e. you don't have the data, we can't do it. Modes are outdated. Look at intercity transport, etc. for all modes. Use the National Transportation Policy (NTP) clusters.

**Jacoby:** I would disagree with that. When I look at these modes, I see expenditures; highways equals roads, not cars; air equals airports, not planes. These are all physical projects.

**Gelston:** But you've got to account for privately provided physical goods even so.

**Grambsch:** But you want to focus on Federal infrastructure projects. You can't disentangle public and private, but you also need to focus on projects dominated by Federal expenditures.

**Gelston:** But you can't double-count and take credit for private investments.

**Grambsch:** Yes, we're aware that just because the Federal government puts in the last dollar, the Federal government does not get all the credit. But we still need to focus.

**Blechman:** Is this is a disagreement about content or semantics?

**Rubin:** We can accomodate both positions. Let me distinguish between the implications of the data and the models themselves. We can't run the models without data.

**Jacoby:** You're suggesting that we start at the synthesis level, not the informational level.

**Williams:** We have a serious problem here in transit. We collect information system-wide, not on a functional or service basis. Transit fares particularly badly in competition with highways. Transit does not look good under Fragile Foundations categories. You've got to be aware of this in your work.

**Jacoby:** Are we not centering on the physical assets?

**Blechman:** Fred, is there a semantic change that would make you happy?

**Williams:** What I've suggested already: intercity, suburban, urban travel mobility, not modes.

**Aschauer:** But you would characterize investments as physical assets, yes?

**Williams:** Yes, but let me give you an example. New systems look very bad because they take place concomitant with new highway investments. That dissipates the impacts of transit.



**Blechman:** These are technical issues.

**Williams:** No, ISTEA requires us to think intermodally, and thinking intermodally will lead to different results.

**Bell:** But to get there, you need good service quality and performance data, and we just don't have it.

**Rubin:** But you get there using case studies. You can't get there systematically.

**Jacoby:** You can get there by quality-weighting the physical inputs. I hesitate to use the word "hedonic".

**Williams:** Look, I work in a policy office. Should we be talking about highways versus mass transit? No! We should talk about intercity travel and commutation.

**Bell:** So we say that these investments work together to improve productivity and we try to illuminate it.

**Williams:** But I'd like to make sure that this issue gets looked at. You say you can do a useful study using useless data. I have tons of Section 15 data and I don't use it. It tells the wrong story.

**Blechman:** Cameron, what is the basis for these categories? Can we change them? Should we?

**Gordon:** We're not beholden to them. Should we change them? I don't know. We were sticking to precedent and building on past work by using these categories, but if it is useful and doable to change them, I'm for it.

**Blechman:** But could you collect data this way and do output another way?

**Gordon:** My gut reaction is to say yes.

**Williams:** Within DOT we don't look at highways, we look at the Congestion Mitigation and Air Quality Program (CMAQ), the National Highway System (NHS), and so on. They are not distinct modes, but rather problems to be solved.

**Lyon:** You're saying that money is fungible. But don't you choose among projects and in so doing, modes?



**Williams:** But that level of disaggregation is arbitrary. Why not go down to the types of metal for trains versus cars?

**Blechman:** Is this an issue of proper study outputs?

**Williams:** Look, some investments are different than others. Congested urban area investments have a clear productivity basis; rural buses may not. I think we should work backwards from the dependent variable, - productivity - and not forward from data limitations.

**Rubin:** What's lost by organizing inputs by the NTP clusters and letting the data workers and modellers work ahead from this?

**Jacoby:** What gets lost, and maybe it should be lost, is the program focus. But can it even be done?

**Munnell:** I think Fred makes an excellent point: organize to get what you want and need and act accordingly. If you can't say anything, don't.

**Schilling:** Policy studies of what is and what could be can't be constrained by the data, but have to be informed by it too. It cuts both ways.

**Blechman:** Are there any comments on modelling?

**Munnell:** Should we set up the B/C analysis and production functions as competing models? They are not competing.

**Gordon:** The study was set up that way to address a perceived competition between models which perhaps a controlled comparison could illuminate, not to imply that the methods are not complementary.

**Grambsch:** I agree; the models are not competing. But we are fundamentally looking at costs and benefits of these investments and which investments produce broadly defined benefits which exceed broadly defined costs.

**Gordon:** So we should look at benefits and costs and use whatever methods are appropriate?

**Grambsch:** Yes, you are trying to enrich B/C analysis.

**Gordon:** What I hear you proposing is to use B/C as an accounting framework only. Specify all the possible and potential costs and benefits. Then go down each category (whatever these end up being) and use whatever methods you have selected to fully determine those costs and benefits.

**Grambsch:** Yes.

#### *AFTERNOON SESSION*

**Blechman:** What's your perception of this morning's discussion?

**Lyon:** I think the comparison of models would be useful.

**Aschauer:** I agree with Randy. Grandly conceived, B/C analysis can capture the set of values coming out of the production function; but we need to capture the cost analysis to plug into B/C analysis.

**Schilling:** That's closer to what I heard. We're shooting for a conceptual ideal of B/C analysis. To get there, we need to do a comparison.

**Jacoby:** Wait a second. If you do some report purporting to show agencies how B/C analysis should be done, that won't fly.

**Gordon:** I think discussion of the way Federal agencies do or should do B/C analysis is a separate issue from our effort here. The Corps has engaged the Advisory Commission on Intergovernmental Relations (ACIR) to do a separate effort where agencies will compare notes on their current B/C practices and hopefully reach more consistent and better practices in the future. Here we are trying to get a handle on how Federal infrastructure investments make us better off. B/C is a useful accounting framework in this sense. One reason that you do a comparison to start off with is to suggest connections you hadn't thought of before.

**Grambsch:** I think we are in agreement that the tasks of the study will not change. We may have to change what to highlight, namely the challenge versus the integration of results, but the nature of the project hasn't changed.

**Blechman:** Let me characterize our consensus as to the ultimate goal: we're trying to integrate these two analyses.

**Aschauer:** It's presumptuous to say that we're integrating these methods.

**Bell:** We don't have to integrate or compete; we're simply trying to understand the benefits of infrastructure better, using a B/C framework. We're not trying to reconcile any perceived polarization of methods, but trying to improve how we think about things.

**Grambsch:** We may not integrate the methods, but examine the insights of different approaches to reach a fuller understanding of infrastructure's effects.





**Bell:** We won't integrate methods or results to get to some higher truth. We will strive to understand the economic mechanisms better.

**Schilling:** We're not testing to get some perfect model.

**Lyon:** I thought we were trying to test, as in growth accounting, to figure out the components of a 30% rate of return and find the spillovers.

**Schilling:** That implies choosing something better.

**Lyon:** Sure, but it's like choosing between linear and nonlinear programming. One is less accurate but simpler; the other more complicated, but more accurate.

**Blechman:** Let me see if this is a consensus. Our goals then would be to learn what we get from infrastructure and compare methods. We are asking the question of how the methods interact with and complement one another. The final product addresses both.

**Grambsch:** One leads to the other in part and the goal seems to be to gain insights, not improve methods.

**Blechman:** Yes, but there is a real distinct interest in methodology in this group.

**Jacoby:** Look at the proceedings. Last time we didn't get to the synergy of the models.

**Grambsch:** I agree; different tools answer different questions. Depending on the aspect you're looking at, you choose a different method. One insight you may gain is to determine which tools are best for which tasks.

[At this point, the group broke up into management and technical committees; Robert Pietrowsky led the discussion in the management committee and Cameron Gordon led the technical committee. Reports from the committees were subsequently given to the floor.]

**Gordon:** I promised the technical committee to revise the scope of work and to meet with Apogee to begin to discuss execution of the work, with one contractor being the lead and others being subcontractors. I said I anticipated a reasonable requirement of technical committee members was to meet, in person or by phone, once a month on average and intensively review and comment on various outputs prior to those meetings. People accepted this as a commitment they could make. I also promised to deliver two items to the committee for their review in the next few weeks: a revised scope of work and workplan for final review, a review summary and announcement. Given some out-of-town members, our next meeting would probably be by conference call.

**Pietrowsky:** The management committee generally agreed with the three action items enumerated by the technical group, but we differed with them on the priorities to be assigned. Due to the potential for delays associated with interagency coordination, we felt that it was important to put together the think piece to be used in the study announcements as a top priority.

We agreed that it will be important for all agencies to confirm committee representatives with a need for continuity of membership and objectiivity. We closed with a brief discussion of the mechanisms available to formalize agency participation if needed, through the execution of memoranda of agreement or understanding (MOA's or MOU's).



## **APPENDIX C: BIBLIOGRAPHY ORGANIZED BY TOPIC**



## APPENDIX C

### INFRASTRUCTURE'S ROLE IN THE ECONOMY: A SELECTED BIBLIOGRAPHY ORGANIZED BY TOPIC

Note: References below are classified as being principally about economic growth and development; international comparisons; literature survey; policy; pricing; productivity; regional performance; sectoral performance; transportation; urban economics; or welfare economics. Of course some works cited below may have more than one principal focus. Nonetheless, one principal focus has been assumed for the purpose of organizing works below. Citations are not repeated in more than one category.

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